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CONTRIBUTIONS TO THE HISTORY OF THE WORSHIPFUL COMPANY OF SPECTACLEMAKERS

(SECOND PAPER ON THE COURT COLLECTION)*

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ABSTRACT. The Worshipful Company of Spectaclemakers in London seems to have been originally modelled after the very old optical centre in the Netherlands. In this way some similarities between the rules in London and in Nürnberg are most easily explained. The principal object of the old guilds was—as it seems to us—to enforce absolute equality of all the members; Master and Wardens had great power, and we have ample evidence of the fact that such rules were strictly enforced in London also. The splendid trade opportunities of the metropolis, especially for more elaborate optical instruments, and the connexion with some of the learned members of the Royal Society, tended gradually to promote the glass grinder to master optician. Some interesting details as to the opticians' signs and to the present coat-of-arms of the Company are given. The continuation of old rules, and the different ways of obtaining the Company's freedom, could hardly raise its status, but, by means of individual enterprise and ability, many members made themselves famous as master opticians. They opposed P. Dollond's aspirations quite unanimously, although ineffectually. If we compare the development of the old Guilds on the Continent and in London, we see how necessary it was to do away with the antiquated rules—deduced as above—of upholding absolute equality for all members.

Introduction

ALTHOUGH it may be said that the contents of the following pages refer only indirectly to the immediate object of the Court Collection, i.e. to further the knowledge of old historical instruments, we are nevertheless of the opinion that the data brought forward will materially serve our object even in this indirect manner.

As the Worshipful Company of Spectaclemakers continued to represent the spectacle-making industry far into the eighteenth century, although their members gradually ceased to further their interests in the old ways which were prescribed by the laws and by-laws of the first half of the seventeenth century, it will be of interest to follow the slow and hardly perceptible process of alteration.

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* [The First and Third Papers on the Court Collection were published in Vol. xxx, Nos. 1 and 5 of the Transactions respectively.—ED.]

In addition to the light we are able to throw from the Company's books on the way in which useful knowledge was spread to the individual members of the optical community, we shall be able to give the names of the principal freemen of the Company and information about them, and at the same time refer to the most important of the independent opticians. The development of the optical trade in London was with these last named, and we shall see that the relations of the Company to the important optical handicraft of the metropolis grew less intimate, the nearer we approach the dawn of the nineteenth century.

Formation of the Worshipful Company of Spectaclemakers in London

There is great difficulty in treating the earlier history of spectacles and everything connected with it due to our ignorance of the development of the important centres of the trade on the north side of the Alps. We believe that in the Netherlands (Antwerp and its neighbourhood) a very important centre was established in the middle of the fourteenth century, and from about that time eye-glasses were being largely exported into the neighbouring countries. It has been shown that, soon after the invention of printing, the art of spectacle making spread from this centre into both Germany and France. The relations of the spectaclemakers in the Netherlands and the South German Free Towns being much better known, we can say that not only the technique of spectacle making was communicated to these places, but also the by-laws of the Netherlandish Spectaclemakers' Companies were the model upon which the regulations for the Nürnberg and Regensburg guilds were formed.

We may surmise that a similar influence was exerted on the French and English spectaclemakers and may in this way satisfactorily explain the inherent similarity of the old rules of the Spectaclemakers' Companies in the different countries. As we have already pointed out in the First Paper on the Court Collection (1), our knowledge of the English spectacle manufacture in Queen Elizabeth's time is deplorably scanty; there must, however, have been a remarkable development in these shadowy times, for in 1629 the Spectaclemakers' Company springs into existence as a body with twelve functionaries.

Personal data before the year of the Charter are very few and far between; by a good chance we know from an entry in the churchwardens' account of St Ethelberga's Church of one Thomas Peale, who was described in 1623 as a spectaclemaker or eye man.

In the year of the charter Edward Gregorie was the first Master and in Mr L. Laurance's paper (2) the two first Wardens, Robert Alt and Thomas Fisher, are mentioned; John Turlington's father was one of the Assistants and Thomas Copley the Clerk of the Company.

The names of a few members of the Company of the time before the great fire have been saved, but our principal knowledge is derived from the years after 1666.

We have compiled a list* of the more important members, arranged chronologically as far as possible, but in many cases our knowledge of the life and of the time they were actually in business is exceedingly scanty. Each member has received a number according to his place in the chronological arrangement and by this means it has been possible to give in a small compass the necessary references to the master to whom he was bound and to his own apprentices. An alphabetical index† to the names in the list has been added.

We cannot say for certain to what extent the Company's books furnish a complete record‡. Some dates are certainly wanting, and we cannot say whether the names preserved represent a fair percentage of the totality of the freemen. The numbers we can derive from the list are no doubt too small, as we did not dare to give to every apprentice taking up his freedom an average length of life. We hope that someone may present us in future with some useful relative numbers to show the gradual development of the Spectaclemakers' Company. He too will probably come to the conclusion that the optical growth of the Company became less and less from the second half of the eighteenth century, as we have tried to point out in another part of this paper.

We thought it advisable to insert in the list the names (with roman numerals) of the more important opticians not belonging to the Company§. As here also our knowledge of the time they were in business is defective, we could not insert them with great exactness.

Regular Contributions (Quarterage) of the Masters to the Company

A perusal of the notes taken by Mr Laurance from the by-laws ((2), p. 155) shows that the control of the Company over its members was quite strict at the beginning. We gather that the contribution due was a shilling a quarter. It seems as if the members were often remiss in making their payments, and in many instances from 1694 to 1774 freemen were summoned for their arrears; some examples are given in Table I. Sometimes costs were imposed but, on the other hand, due consideration was taken if such a brother was incapacitated for work by illness or infirmities. In 1757 one brother, J. Phipps, paid a sum of £2. 15*s*. 6*d*. in advance, which is equal to about 14 years' due. As he was then 55 years of age, it appears that the payment was asked for up to the 70th year.

The duties of Master and Wardens were at that time heavy in hunting up bad spectacles, and as a kind of compensation they were allowed to have a second apprentice without extra payment. Whether any amount had to be paid in taking up one of the official posts, we do not know for certain; in 1749 there is a charge of £5 against E. Nairne when he was elected as Assistant. If any member was elected as an officer in the Company and declined to serve, the Court had the power of exacting heavy fines (usually not mitigated), as Table II shows.

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* See p. 71. † See p. 88.

‡ We have since been informed by Mr Under Sheriff W. H. Champness that the Company's records form a continuous series from 1669 with very few blanks, and that during most of the period the names of freemen in particular were regularly entered.

§ This has been Mr Court's work, in the same way as the difficult collection of that part of the information relating to the members of the Spectaclemakers' Company not found in any of their journals, and in many cases he has been able to give details of their later business careers, etc. If, therefore, a considerable part of the optical history in London, and certainly the part belonging to the more successful English opticians, has been saved, this is due to Mr Court's indefatigable exertions.—M. v. R.

Table I. *Members summoned for arrears*

Name	Year	Particulars
J. Alt	1694	Granted a release on account of his infirmities
J. Harris	1703	Fined £3. 10*s*. for being in arrears; reduced to £1. 10*s*.
S. Brown	1732	Heavy costs imposed
G. North	1738	
M. Richardson	1742	Allowed to pay arrears by instalments of 6*d*. per week
O. Coombs	1742	
F. Watkins	1774	

Jurisdiction of the Court over the Members

The jurisdiction of this Court was also strict in cases of smaller offences; for instance, in 1688 a brother who, being summoned, did not come within one hour, is fined 1*s*. Members of the Court not attending the Court sessions are fined 5*s*. a year.

Table II. *Regarding the jurisdiction of the Court*

Name	Year	Particulars	Fine		
			£	*s.*	*d.*
J. Howe and J. Verney	1674	Elected as Stewards; declining to serve	5	0	0
W. Radfort	1724	Elected, declining	10	0	0
		fine reduced to	3	12	0
W. Eastland	1737	Having refused to serve as an Assistant	11	4	3
J. Phipps	1739	Excused from acting as Warden or Master	10	0	0
— Handford	1688	For not coming within one hour of being summoned (six others were summoned at the same time)		1	0

In comparison with other City Corporations—for instance, the Clockmakers' Company which was founded in the same year—the Spectaclemakers' Company developed under favourable circumstances, for no other Company felt itself injured by this new foundation; it was, therefore, not necessary for them to fight their way as, for example, the Clockmakers were obliged to in defending their rights against the aspirations of the Lockmakers. On the other hand, it had the disadvantage that the simplicity of the occupation of lens grinding made it difficult, if not impossible, to substantiate a claim to be a skilled craft of equal merit to some of the other handicrafts. Presumably, therefore, the Spectaclemakers' Company was considered as of but a modest standing, and we intend to show this presently by discussing such knowledge as we have of the apprentices' status.

Status of the Company as a City Corporation

The handicraft of this guild consisted in the first half of the seventeenth century of a somewhat crude method of grinding lenses on stationary iron tools, of polishing them, probably with tripoly and tin oxide, and then of mounting the lenses in horn mounts. Such rims appear to be the oldest and most approved, if we may judge from the old reports of the Court sessions held towards the end of the seventeenth century. We note in passing that the appearance of eye-glasses of London manufacture of about the middle of the seventeenth century is not known. We may suppose that they were rather uncouth, as the guild does not seem to have formulated binding rules for the "master-pieces" to be made at the close of an apprenticeship.

As far as we know there is only once any hint of the "pieces" for a master workman ((2), p. 156), but no details are given. As late as 1671 we find the following reference to work done by the spectaclemakers: "Watch glass making; grinding was a practice of the Spectaclemakers' Company."

Apprentices and Journeymen

Even if free of the Company, the young journeyman was ((2), p. 156)—as in other guilds—bound to serve a master (usually the one to whom he had been apprenticed) for two more years before he could apply to become a master workman. In general, the master was not allowed to have more than one apprentice on his premises, except that towards the close of an apprenticeship he had the right to take on a new boy. It would appear from particulars regarding members between 1679 and 1760 that the master who, for the first time took an apprentice, had to pay £2. The same fee seems to have been imposed if a master wanted to take over an apprentice from another master. That there normally was a fee is distinctly stated, and in one case the amount is given as £2. In general, the boys began to serve at 16 years of age, so that they could take up their freedom at the age of 23; sometimes they were made free earlier, at 21 years; but, as this is expressly mentioned, it was no doubt considered unusual. If a master employed a youth a year younger, i.e. at 15 years of age, he had to pay, as far as we can judge, a guinea as fee. It was considered an offence to employ a boy not bound as apprentice; we learn that fines between 2 guineas and £5 were imposed, but in the cases known to us they were considerably mitigated. There seems to have been a fee of 2*s*. 6*d*. payable in taking a new apprentice in place of the old one who had completed his apprenticeship, as we find such payments between 1682 and 1760. If the master wanted to employ a second boy for business purposes he was—according to our knowledge—allowed to do so upon payment of a comparatively heavy fee of £3*, and of £4 for the third. Some examples are given in Table III.

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* According to Mr Champness, the fines payable on taking a second youth seem to have varied according to circumstances.

We must, however, expressly state with regard to these tables that the information we have does not seem complete, and that we cannot therefore be certain of our conclusions.

Table III

Name	Year	Particulars	Fine		
			£	*s.*	*d.*
J. Hayward	1669	Made free, 21 years of age and being married			
S. Hawes	1679	Made free by patrimony, about 21 years of age			
G. Tengay	1682	For — Pateshall		2	6
C. Cock	1691	For E. Scarlett		2	6
P. Eglinton	1760	For his son being bound to him		2	6
G. Tengay	1679	For Sprat	2	0	0
S. Thompson	1694	For the first apprentice	2	0	0
G. Willdey	1706	" "	2	0	0
M. Loft	1724	" "	2	0	0
H. R. Shuttleworth	1760	" "	2	0	0
T. Ribwright	1736	For the second apprentice	3	0	0
J. Tomlinson	1757	For the second apprentice (for one run away)	Free		
J. Tomlinson	1758	For the third apprentice	4	4	0
— Scatliff	1737	For changing apprentices	Amount not stated		
T. Ribwright	1741	" "	Amount not stated		
J. Cox	1743	For taking over J. Marges	2	0	0
J. Cuff	1745	" "	Usual fine		
T. Lincoln	1738	For employing a youth a year before his time	1	1	0
E. Nairne	1751	" " "	1	1	0
T. Lincoln	1754	" " "	1	1	0
G. Sterrop	1754	" " "	1	0	0
E. Nairne	1759	" " "	1	1	0
J. Aldridge	1669	For an apprentice not bound		?	
J. Jones	1759	" "	2	2	0
		Fine reduced to	1	1	0
		J. Jones not being in good circumstances			
R. Linnell	1759	For an apprentice not bound	5	0	0
		Reduced to		19	0

There is no doubt that by these laws the freemen of the Company were effectually protected against undue competition by the other freemen or brothers. Anyone who had been apprenticed without taking up his freedom was called a foreign brother; such a person was allowed to make and sell his goods outside the City walls only*. In the earlier times it was therefore necessary for a spectacle-maker who was doing a large trade to take up his freedom, but as the populated area widened outside the City walls, it became less necessary to take up the Company's freedom. We find from reports of the Court sessions in the second half of the eighteenth century—especially in 1771—that at that time a number of apprentices had not taken up their freedom, although they had served for more than the necessary number of years. For example, in 1771 Blunt (with others) was ordered to take up his freedom, having served full time and Richardson was ordered to take up his freedom.

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* According to Mr Champness, there were some portions of the City outside the walls within which a "foreigner" could not trade. For example, although the walls on the west were built at Ludgate and Newgate, the City boundary extended farther west to Temple Bar and Holborn Bar.

Ordinary Retailers and Spectacle Shops Proper

The spectaclemakers do not seem to have sold the greater part of their goods directly to the customers, but to have supplied shopkeepers who acted as retailers, especially haberdashers. We may suppose that these optically uninstructed persons had some rules for prescribing spectacles, probably merely according to the age of the buyer, in order to supply them without too great blunders, but we have no direct knowledge of such rules in England.

The first spectacle shop of which we have any notice was that of Thomas Peale, one of the first Assistants at the time of the Charter; he was certainly in business by 1623 at one of the shops under St Ethelburga's Church, Bishopsgate, as his name appears in the churchwardens' accounts for that year. Richard Reeves was in Long Acre about 1663–5. He sold telescopes, microscopes, magic lanterns, and other optical instruments. John Baly (sometimes Balie) in 1664 kept a shop (for the sale of spectacles, telescopes, etc.) in St Paul's Churchyard, and there are a number of other spectaclemakers' shops known to us, but it was not till about 1675 that John Marshall opened a shop at the "Sign of the Gun" (a very unusual sign for an optician's shop) for the sale of optical goods on a large scale. About the same time John Yarwell had a shop in St Paul's Churchyard. We may suppose that the importance of this departure from the status of outward equality prevalent till then between the brothers was not appreciated at the time; it was in fact the beginning of an entirely new development: such a master-artisan, well educated in the use of different instruments, inventive, and moneyed more or less, was necessarily quite distinct from the rather crude member of the mass of spectaclemakers found at the time of the Charter.

The first early step was taken in London between 1640 and 1660 when special masters, such as Reeves, obtained a great reputation in the construction of telescopes and microscopes. We know that clever men of this type came into contact with the leading spirits of the Royal Society, and as they were by these means necessarily schooled in theoretical optics and mechanics, and also acquired the highest degree of skill in manufacture, they were far ahead of the ordinary optical journeyman.

We are not certain whether such artists—and scientific men down to the time of Thomas Young used to apply this title to the master opticians—held themselves aloof from the Company in the early days; indeed it is very likely that the greater trade facilities enjoyed by the Company's members induced such people to take up their freedom, but the germ of a completely different view as to the status of a manufacturing optical instrument maker began to grow. As far as we are able to judge, this difference of view showed itself first in the way the functions of the Society's officials were fulfilled.

Supervision by Master and Wardens

When the Charter was drawn up, the principal duty of Master and Wardens was—as already hinted—to ensure the members' equality. They were authorised by their own laws and by the unquestioned customs of the City to search not only the workshops and the (rare) retail places of the members proper but also the places of the retailers, especially haberdashers and other shopkeepers. If nothing unlawful was found the shop searched had only to pay 4*d*. for the search. This duty evidently took a great part of their time, and Master as well as Wardens were therefore allowed to have a second apprentice without being obliged to pay a fee for this privilege. We may suppose that in the early times the work was without great individuality, and that the master could be temporarily replaced by the workman without much loss.

It is true that the perfectly ruinous fines against unlawful spectacles ((2), p. 155*r*) were not continued with the same rigour, but even the lesser amounts given in a note of October 1671 are very heavy. As this note is of great historical value, we subjoin its text:

	£	s.	d.
Three paire of Spectacles in black frames the workmanship of the glasse being imperfect and they valued at 5^{s} per dozen according to the ordinances he is Fined double the value w^{ch} is		2	6
four paire more of black slitt frames at		5	4
five paire of 4 slitt frame Spectacles at		8	4
four dozen of white ordinary Spectacles at	1	7	0

As far as we can judge from the (very small) number of decisions known to us, these officials were very strict in their duty: they condemned not only spectacles imported from other countries but also home-made goods, if they happened to be given to the trade under conditions different from the general custom. It was unlawful to sell frames or glasses alone, as evidently the fitting of the glasses in the frames must not be done by unskilled hands; it was unlawful to sell spectacle glasses ground to a sphere on one side only and plane on the other, as evidently the members all had to work under the same conditions, i.e. to make the time-honoured bi-convex glasses; it was unlawful to sell leather frames, although they were better to wear and not so breakable, as evidently the old type was a horn mount, and the older members objected to the easier and more agreeable way of the young innovators. Some cases of defaulters and the fines imposed are given in Table IV.

Change of Status of Members becoming Master Opticians

The freemen of the younger generation—and especially gifted people like Yarwell and Mann—strongly objected to the above strict practice, and in some cases (as shown in Table IV) successfully carried their point. It is hardly probable that these men, when in the course of time elected as Master and Wardens, should have been very strict in enforcing the old customs that they themselves had opposed with so much spirit. Also, when men of this type became master craftsmen, their time was so valuable that the makeshift provided by the founders of allowing him a second apprentice without fee could by no means compensate him for the pecuniary losses incurred in hunting up bad or indifferent spectacles. As the optical

Table IV

Defaulter's name	Year	Particulars	Fine		
			£	*s.*	*d.*
J. Clark	1667	For 16 pairs of spectacles made of looking glass (one side ground only); fine mitigated			
J. Clark	1669	Fined for many bad spectacles			
J. Clark	1670	Fined for selling 3 pairs of spectacles made of looking glass	3	0	0
J. Penny	1670	6 pairs of bad spectacles found at a haberdasher's shop; they were razed			
J. Penny	1670	For making and selling one dozen bad spectacles		7	0
— Gardner	1670	For making and selling 3 pairs of bad spectacles (reduced to £2)	3	0	0
W. Jenkins	1670	6 pairs of bad spectacles found at a haberdasher's shop			
J. Whitehead (haberdasher)	1671	10 dozen French spectacles with tin frames broken(3)			
E. Bagnall (haberdasher)	1671	22 dozen bad English spectacles openly broken with a hammer			
H. Bolter	1671	For 80 dozen frames without glasses(3)	2	0	0
J. Tailor	1671	Bad spectacles at the search in an haberdasher's shop, Grub Street			
— Hickett	1671	For making bad spectacles	2	3	2
J. Tailor	1677/8	For selling spectacles to a non-member	2	0	0
J. Yarwell	1692	6 pairs of leather frames were taken from his shop			
C. Cock	1692	Leather spectacles objected to as unlawful, an innovation, and prejudicial to the trade. Shall action be taken against it?			
W. Bembrick	1695	4 pairs of black spectacles taken			
J. Mann	1695	Fined for making and selling 31 pairs of white spectacles ground only on one side and 5 pairs of black spectacles, being unlawful and bad wares			
J. Mann	1697	Expelled and disowned from being an Assistant for selling a great quantity of improper wares, viz. frames without glasses to persons not free of the Company			
J. Mann	1702/3	The Court have rescinded their decision and it was ordered that frames without glasses and glasses without frames may be sold without the Company taking action.			
	1702/3	J. Mann admitted once more as Assistant			

handicraft in London was now concerned with so many more valuable commodities, viz. telescopes (refracting and reflecting), microscopes, perspectives, camera obscuras, scioptric balls, etc., the simple eye-glasses were rather looked down upon, so that the interest in strictly enforcing the old rules of search and condemnation died away. We may explain in this way the absence of any of the fines for bad spectacle work in the eighteenth century, which had occurred in the seventeenth century with considerable regularity and in amounts that must have been quite ruinous if actually insisted upon. This laxity drew into England a number of cheap foreign spectacles. The pair of Fürth-made eye-glasses in the stone coffin points to about 1730 as the *terminus post quem*, but we should not think a great time could have elapsed as these nearly valueless goods were turned out of Fürth in very quick succession and nobody was supposed to keep them in stock for a prolonged period. As their quality was not to be compared with that of eye-glasses sold in London shops of good repute, we must suppose that the foreign wares were sold to the lower classes; Goldsmith's story of the gross of silvered spectacles sold at a fair may indicate how these cheap imported goods may have been distributed without the help of the well-established shops.

Company's Freedom by Servitude, Patrimony, and Redemption

With regard to apprentices the general London rules as to the length of the "servitude," the two years' service as journeymen, etc., had been, as shown above, enforced in the optical trade. If the master died within the time of the indenture, the apprentice was in general turned over to another master who could testify for the time served by the apprentice when applying for the Company's freedom. That originally some kind of examination had to be passed before the freeman was declared a master workman may be concluded from Laurance ((2), p. 156), but we have not come across any note of this kind in later times. We suppose that the apprentice had to pay a certain small sum, which between 1681 and 1771 varied from 13*s*. to 17*s*. 4*d*. This freedom by servitude was the ordinary and (in our judgment by far) the best way of obtaining the freedom. There were, however, two other possibilities, the freedom by patrimony and the freedom by redemption* (simple payment without previous instruction) and they will have contributed towards the indifference that the opticians proper began to show with regard to the Company. Even if we allow that, in the middle of the eighteenth century, the sons and daughters of a master optician will not have taken up the freedom without some training, we must consider as a concession of very doubtful value the possibility of obtaining the freedom on a lesser degree of instruction in consequence of some family relationship to a recognised optician. The decay of the Nürnberg factories in the seventeenth century is largely to be attributed to the undue influence of family relations, which prevented the selection of the fittest. As the keen competition in London prevented such a stagnation, the trade did not suffer so much, but the status of the Spectaclemakers' Company underwent a considerable change. There is hardly any question that the freedom of the Company had not the same value in the journeymen's eyes during the latter half of the eighteenth century as it had in earlier times; we may entertain doubts whether this indifference could be successfully contested by the official regulations that are sometimes quoted.

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* According to Mr Champness, freedom by redemption was taken up by practising opticians as well as those who were not opticians.

Unavoidable Alterations in the Number of Apprentices and Journeymen

The number of apprentices allowed to a master optician does not seem to have been very strictly adhered to, although we are not in possession of sufficiently accurate data to give exact numbers. Women were instructed in the grinding processes, and one master, David Court, derived quite a competency by teaching to apprenticed girls the methods of grinding and polishing lenses. The members appear to have been very lax in allowing him to teach so many apprentices, and in fact we do not know that any official objection was raised. During the eighteenth century we often find premiums paid to the master for the indentures. Some successful masters asked sums as great as £100 to £200, a very considerable amount in those days.

As we both were interested in these numbers we worked through the names of those about whom we have particulars, taking down the time and the amount of every premium paid for the apprentices. Although the numbers are hardly complete, they do not seem to be valueless. We found 52 cases altogether, and they were distributed chronologically in the following way:

1730	1731–5	1736–40	1741–5	1746–50	1751–5	1756–60
1	7	7	4	7	7	3
1761–5	1766–70	1771–5	1776–80	1781–5	1786–90	
1	2	8	2	1	2	

The increase about 1771–5 is to be explained by David Court's practice, who taught women apprentices the art of spectacle making for rather high premiums.

As to the amount, we arranged the smaller sums—under 50 guineas—according to a scale in guineas in steps of (generally) 5 guineas. In the last four cases the above-mentioned very high premiums in pounds were arranged for.

Sums in guineas	5	10	15	20	25	30	40	45	50
	9	8	2	9	1	7	7	1	2
Sums in pounds	70	100	150	200					
	2	1	2	1					

Opticians' Signs

About the year 1675 John Yarwell opened a shop for the sale of optical instruments. As was the general custom at that time, he chose a sign for his optical shop. It was called "Archimedes and Crown" and showed Archimedes observing through a refracting telescope of considerable length. In the four corners of his sign we find four pairs of split spectacles in tortoise shell rims. This sign was to serve as a model for many opticians' signs, as may be seen from Table V. There were simple

Table V

Sign	Owner	Time	Address
The Golden Spectacles	John Radford	1668	Without Temple Bar
,, ,,	Nathaniel Adams	1737	Charing Cross
,, ,,	Thomas Ribright	Before 1760	At the Poultry
Great Golden Spectacles	James Ayscough	Just after 1747	Ludgate Street
The Spectacles	Oliver Combs (from Mr Scarlett)	About 1750	Second House from Essex Street, near Temple Bar
Great Golden Spectacles and Quadrant	Joseph Linnell (successor to the late James Ayscough)	After 1759	
Reflecting Microscope and Spectacles	John Cuff	1752	Against Sergeant's Inn Gate in Fleet Street
The Archimedes and Crown	John Yarwell	1675	
The Archimedes and two Golden Spectacles	John Marshall	1690	Ludgate Street
The Archimedes and Three Pairs of Golden Spectacles	Ralph Sterrop and John Yarwell	1697	Ludgate Street
The Archimedes and the Globe	E. Scarlett	1705	Dean Street, near St Anne's Church, Soho
The Archimedes and Globe (Spectacle and Toy-shop)	George Willdey and Timothy Brandreth	1706	Ludgate Street, Toy-shop next the Dog Tavern
The Archimedes and Spectacles	T. Gay	1723	Near the Sun Tavern behind the Royal Exchange
The Archimedes and Two Pairs of Golden Spectacles	James Mann, jun.	1735	Near the Castle Tavern, Fleet Street
The Archimedes and Three Spectacles	Francis Morgan	After 1766	No. 27 Ludgate Street, near St Paul's
Friar Bacon's Head	Samuel Scatliff	1740	Corner of St Michael's Alley
Tycho Brahe	Dudley Adams	1798	No. 60 Fleet Street
Sir Isaac Newton's Head and two Pairs of Golden Spectacles	James Mann, jun.	1736	St Paul's Churchyard
Sir Isaac Newton's Head and Golden Spectacles	Matthew Richardson (late apprentice to Mr Scarlett)	About 1745	Against York Buildings in the Strand
Sir Isaac Newton's Head	F. Watkins	1747	Charing Cross
Sir Isaac Newton and Two Pairs of Golden Spectacles	Samuel Johnson	1765	Near the West End of St Paul's

signs showing spectacles alone, or (in some cases) combined with an optical instrument. The greater number of the signs, however, were adorned by some personality such as Archimedes, Friar Bacon, Tycho Brahe, or Sir Isaac Newton. Such a renowned name was often connected with "spectacles," evidently as representing the optical goods in most general demand. Archimedes especially seems to have fascinated the craftsmen, and we find his likeness on a comparatively late sign like that of F. Morgan. These signs of course exist no longer and we shall have to relate how they were done away with soon after the middle of the eighteenth century.

The signs are always represented on the shop prints of the owners. These are advertisement sheets with the sign and a representation of the goods sold at that shop. The reason for the sign was that in the seventeenth and at the beginning of the eighteenth century there were no house numbers in the streets, and this was how the individual house was indicated. Shortly afterwards, some description of the goods or of the improvements introduced by the owner was added, and for a time it became customary to give these descriptions in two or three languages. French was always chosen for the second language; as third language we sometimes find Dutch and sometimes German, and this gives some indication of the countries most important to the trade. These shop prints—they were mostly given away—are very valuable documents, as they give us an insight into the optician's trade that would otherwise be hopelessly lost. They furnish us documentary evidence in the same way as the Nürnberg covering papers for the spectaclemakers' goods. Although these begin a little before the English shop prints, the latter have the advantage of a much better and more careful execution, and they tell, so to speak, a longer tale, as they generally contain a greater variety of goods. Such evidences are of the very highest importance for the Company's history, e.g. the representation of the first pair of temple spectacles about 1728 has been saved by means of these shop prints, although they were certainly not valued at that time. However, the experienced collector* will not necessarily take the signs and shop prints as trustworthy evidence, for in many cases such representations may—with or without intention of the designer—be considered as older than they really are. This may arise from the fact that the copper-plates of old shop prints were used again quite naïvely with comparatively small alterations by later opticians, or even that the designer may have cunningly tried to convey the impression of an old and therefore more imposing place of business. It is in this latter manner that we must probably explain Morgan's sign on his shop print. It is most improbable that the old split spectacles (with also the borrowed inscription "The Right True") had any considerable sale at the middle of the eighteenth century, and Morgan evidently wished his place of business to appear older than it really was.

The use of signs was done away with in London about the year 1766, as the creaking noise of the signs swinging in the wind became an intolerable nuisance.

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* I can the less lay claim to this very enlightening criticism, as I myself did not really understand F. Morgan's sign when I first came across it. I learnt from Mr Court the right way of looking at such documents.—M. v. R.

At that time street numbers were introduced to the houses and the optician either had to take his sign *into* his shop or place it flat and rigidly fixed to the outside if he wanted to keep it at all. There are some later signs in fact but in general the day of the signs had disappeared and also that of the shop prints. They are followed by advertisements, giving much longer and more detailed descriptions but often unfortunately lacking the drawings. The collector and the historian are not always certain of the real value of this progress.

Company's Coat-of-Arms

The generation coming into authority at the beginning of the eighteenth century—we noticed above that they did not attach much value to the simpler forms of eye-glasses—attached most importance to the optical goods of the better description. It is possibly through their influence that the Company's coat-of-arms was changed to include such later optical improvements as prisms. Any real evidence, however, is wanting. The representation of the new coat-of-arms to be found in modern articles is of a very recent date. It was drawn in 1810 by H. Lawson and it immediately stimulated the London clockmakers to a very sharp attack. An account of the different stages of the contest, in which the clockmakers failed to carry their point, is to be found in Ref. (4). We gather from the statements that no actual knowledge of the early form of the Spectaclemakers' Company's coat-of-arms is forthcoming; like many other details of the old times this too has passed to the *limbus infantum*.

In any case we may be sure that towards the middle of the eighteenth century the Spectaclemakers' Company paid regard to the recent optical inventions which were of much greater importance than spectacles in their highest refinement.

Action of the Company and London Opticians in Peter Dollond's Case

In 1763, after J. Dollond's death, Peter Dollond notified the London opticians that he would sue any craftsman for damages who sold achromatic glasses without paying him royalty ((5), pp. 229, 230). The opposition of the trade to this threat must have been exceedingly strong, as immediately a petition was set up against it. The contents of this document have been published before in consequence of Mr E. W. Hulme's exertions, but we can now give the additional information that the petition was conceived and executed in the Spectaclemakers' Company. The text is as follows: "28 June 1764 Ordered That Mr. James Tomlinson do pay into the hands of Mr. Grub, Attorney at Law in the old Jury The Sum of Twenty pounds towards defrayin (*sic*) the expence of Petitioning the Privy Council to vacate a Patent (obtained by the late John Dolland (*sic*) decd.) for making object glaſses of refracting Tellescopes; And that the s^{d} Sum be allowed at the next Audit."

The co-operation between the master opticians outside the Company was so strong that a considerable number of them signed that document, together with some members of the Company. This is in harmony with our opinion expressed above that the higher education of the apprentices after the introduction of telescopes, microscopes, and reflectors induced them, when in a responsible position, to keep on good terms with the independent opticians outside the city walls who had enjoyed the same education. Undoubtedly the connexion between the members of the Company themselves was weakened by this external co-operation, and it is natural that the value of membership diminished, when the conditions which had prevailed at its foundation were so completely altered. It seems that, about the middle of the eighteenth century, the political and civic rights and advantages that the freedom of the City afforded caused quite a number of people to become members of City Companies, including the Spectaclemakers' Company. They were admitted by redemption, viz. the payment of a small sum, and we cannot doubt that the value of its membership to the members of the optical handicraft was accordingly diminished.

It may be that, in consequence of the greater possibilities open to well-trained opticians as compared with those earlier spectaclemakers' apprentices, the payments mentioned above were demanded on apprenticeship. This is also in accord with our supposition that the old status of the Company was altered more and more by the new necessities for better training that were required to take advantage of the wider opportunities open to the skilled optician.

Upholding of the Old Rules in Nürnberg

It may not be without interest to observe the two ways in which old Spectaclemakers' Companies of different nations attain their end. In the much older Nürnberg Company the want of instruction of the apprentice evidently persisted right from the beginning (about 1498 or so); there is no sign of any superior intelligence or more scientific knowledge exhibited by the masters down into the eighteenth century. They appear to us to form one indistinguishable mass of men, preserving the old rules and methods of the art which had become quite inefficient in comparison with the newer methods developed elsewhere. But, although the members were alike in the want of higher instruction, they did not maintain the social equality exacted in the fifteenth and sixteenth centuries. As eye-glasses of different kinds were the only commodities in which the members were allowed to deal, and as the retail trade in a medium-sized town like Nürnberg was naturally limited, they were compelled to develop a wholesale trade of very considerable proportions. They were, as we pointed out in the First Paper on the Court Collection (1), very far ahead with regard to the manufacture of spectacle-mounts, and managed by division of labour and by clever innovations—nearly all the names of the individual inventors are hopelessly lost to us—to put upon the market eye-glasses of indifferent quality but at a marvellously low price. A number of modern methods of surfacing and mounting were in a crude form made use of by the leading mechanics of these old factories; and they solved the problem (that has arisen again recently) of furnishing a pair of eye-glasses inscribed with a distinct address or sign of the maker. Nevertheless the whole development in the South German Free Towns came to an ignominious end, as the makers neglected quality in the attempt to reduce the cost to the lowest possible one.

Development of Spectaclemakers to Master Opticians in London

The development of the London Spectaclemakers' Company, founded in 1629 (more than 130 years later than the Nürnberg Company), was much more rapid and was effected on quite different lines. As the telescope had been in existence twenty years before the Company was founded, we may consider the rules of the Charter to have been taken from much older ones, which were revised right at the beginning. It was helped by the fact that the Society grew up in the metropolis where the demands of science and trade led the more inventive members to take a greater interest in the new optical instruments, with a view to further improvements in their outward form and their qualities. We must suppose that a guild, which was one of spectaclemakers only, could not be maintained without alteration after the end of the seventeenth century. After that time we recognise the gradual decline of the old foundation, as far as optical interests are concerned, but this divorce of the Spectaclemakers' Company from the optical industry is by no means so fatal as in Nürnberg; on the contrary we see in the eighteenth century the successful development of the master artisan in optics. He is very well instructed, inventive, successful, and he impresses his stamp on the whole eighteenth century, until in the first quarter of the nineteenth century a new and successful form of manufacture is developed that still retains its vigour.

We have dealt in this paper with the history of the Company up to the beginning of the nineteenth century. It may be pointed out that towards the end of the century there was a renewal of its activities and its Diploma scheme has now become well established and has received the approbation of a Government Departmental Committee.

Our grateful acknowledgments are due to the Spectaclemakers' Company for their kind permission to use the many extracts from their Minute books which have so greatly added to the interest and value of this paper. We also desire to state that, whilst part of our information has been derived from papers by L. Laurance and others dealing with the history of the Spectaclemakers' Company and a still further part from notes we have collected for many years with a view to compiling a history of the optical craft in Great Britain, we are especially indebted to Mr Baxandall for the great help we have had from the notes which he extracted from the Company's books. We wish to express our thanks also to Mr Under Sheriff W. H. Champness, Clerk of the Company, for directing our attention to a number of errors in the original draft of our paper and for providing some additional information which has now been incorporated.

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DISCUSSION

Mr R. S. Whipple: This paper emphasises the great debt which all who are interested in the history of optics owe to Mr Court and Prof. von Rohr. I think that the reference in the paper to Mr David Court's employment of women in grinding spectacle lenses must be the first mention of women as workers in the optical instrument industry. The side-lights thrown on the relationships between masters and men by these old guild records are of great interest.

Mr W. M. Brett: The thanks of the Society and of the ophthalmic and optical professions should be given to Mr Court and Prof. von Rohr. There is no doubt that a considerable amount of laborious work has been involved in obtaining the information for which everyone interested is greatly indebted. As a Fellow of the Spectaclemakers' Company, I am sure I shall be speaking the mind of all my colleagues in voicing our appreciation of the work that has been done.

It would probably be of great assistance to future historians if the authors could indicate in an appendix to the paper the ground that has yet to be covered if further investigations are to yield profitable results. Mr Court has made extensive researches, but there are still fields that might be investigated with profit, and any indications along these lines should prove most valuable to further research.

Mr H. W. Dickinson: The authors are to be congratulated on the great amount of research work that they have done; the paper is really a history of early optical instrument making. The Spectaclemakers' Company was a guild and its primary function was to keep up quality. One could not help feeling that the Company had not risen to its opportunities as the optical industry expanded; hence they had not attracted important instrument makers who preferred to remain outside. I cannot understand why the Nürnberg spectacle-making industry decayed. Why did not the guild there step in? The decline of the spectaclemakers was due to causes that had affected all City Companies, viz. divorce from function.

Mr W. H. Towns: It may be of interest to note that, in spite of the decline in importance of spectacle making of which we have heard (although admitting a revival in recent years) and in spite of the great increase both in number and importance of many other optical instruments, the description "optician" still appears to mean to the general public merely a seller of spectacles. May I add that those who have failed to attend this evening have paid the penalty of missing much interesting information, evidently the result of long sustained effort in accumulating, and for which our thanks are due not only to Mr Court and Prof. von Rohr but also to Mr Baxandall for the clear and pleasant manner in which he has put it before us.

Mr Court: In reply to Mr Brett a great part of our information has been obtained from early shop prints and advertisements of the seventeenth and eighteenth centuries, and from scientific books and makers' catalogues, sometimes found bound up in such works; these I have searched fairly thoroughly and therefore think that perhaps there is not much to be expected from these sources. The early wills at Somerset House are not of much use; I have also examined those of the last 150 years. Advertisements in the newspapers, of which there is a large collection in the British Museum Library, might give some good results. The churchwardens' accounts of the various City Churches often have interesting entries, and the Guildhall Library also has a quantity of material dealing with trade in the City of London. In the British Museum there is also a record of about 25,000 claims made after the Great Fire; these might give some useful information if consulted. There is also possibly some good information to be found in the Record Office. What are especially wanted are prints or pictures showing nose spectacles of the fifteenth, sixteenth, seventeenth, and early eighteenth centuries and any scientific instruments bearing names not on the list printed with this paper; in fact, any items relating to these early craftsmen, if jotted down from time to time as met with, would always be useful and might well prove of great value when brought into relation with others.

CHRONOLOGICAL LIST OF THE MORE IMPORTANT MEMBERS OF THE WORSHIPFUL COMPANY OF SPECTACLEMAKERS, INCLUDING THE LEADING INDEPENDENT OPTICIANS

Notes

Numerals in Clarendon type (**1**, **2**, etc.) indicate members of the Company.

Roman numerals (i, ii, etc.) indicate important opticians who did not belong to the Company.

Dates are given in the decimal system (year, month, day); thus 1669. 08. 18 is equivalent to 18th August, 1669. Probable dates are shown thus (1671).

Abbreviations

A. =apprentice(d)
B. =beadle
b. =born
c. =about
d. =died
G.W. =good will
M. =master
N.C. =no consideration
S. =steward
Sp.C. =Spectaclemakers' Company
Sp.M. =spectaclemaker
W. =warden

1. Twigg, Richard (No. 1), **13**'s father, 1670: Bishopsgate.
1669. 08. 18: succeeded **7** as *M.*
1670. 04. 07: *d.*; **13** elected to succeed him as Assistant.

2. Jenkinson, John, 1669: Bishopsgate.
1644: *A.* **10**.
1669. 04. 01: *d.* before.

3. Bourne, John, 1675: Pope's Head Alley.
1691. 09. 30: *d.* before.

4. Tailor, John (No. 1), **40**'s father, 1675: St Amen Lane.
1664: *A.* **34**; 1669: *A.* **40**; (1676): *A.* **49**.
1671. 10. 04: bad spectacles at a search in an haberdasher's shop in Grub Street.
1677/8. 01. 10: ordered to pay £40 for selling spectacles to a non-member.
1681/2. 01. 12: *d.* a little before.

5. Spencer, William, 1668: in the Minories; 1671: Bermondsy.
1668. 04. 20: ordered not to employ Thomas Spencer his son at the trade of *Sp.M.* or anything thereto belonging, as the said son is not at this time an apprentice neither has he served seven years to the same trade (his age is taken here as 21), and if he does employ him any longer, he is to be sued at common law. Ordered to be arrested, £3 owing. Arrested later, paid 10*s.* and promised to pay the rest in quarterly instalments of 10*s.*
1671. 08. 15: employed **43**, a boy about 16 years old who was not apprenticed.
1673. 10. 01: last entry.

6. Hayward (Haward), John, *Sp.M.* 1665, 1669: St Katherine's.
1665: mentioned as *Sp.M.* in catalogue of Beaufoy Tavern tokens, 1689, p. 54.
1669. 10: *d.* shortly before.

7. Turlington, John.
1666: *M.* at the time of the fire.
1668/9. 01. 07: **15** elected as proxy for *M.*
1669. 08. 08: last date as *M.*; **1** succeeded him.

I. Reeves, Richard, 1663: Long Acre.
1663. 05. 17: sold telescopes at £6 each.
1665: worked (together with **44**) for J. Gregory; made telescopes of 40 to 60 ft. length, afterwards followed by **44**. Was known as a prospect maker.

8. Crosby, Henry.
1668. 04. 20: *d.* before.

9. Radford, John, at the "Golden Spectacles," 1668: without Temple Bar; 1670, 1695: St Clement's Danes.
1667. 10. 02: re-elected *W.*
1668: *A.* **38**.
1669. 10. 06; 1670. 09. 16; 1670/1. 01. 12; 1687/8. 01. 19: *M.* See also his halfpenny in Baynes' *English Tokens*, 1889 edition, p. 764.

10. Throgmorton, John, 1669: Tower Hill; 1693: St Katherine's.
1644. 10. 20: *A.* to **2**; left him in the late wars and fought for the Restoration.
1669. 10. 06: member.
1669: *A.* **41**.

11. Alt, Jonathan, *Sp.M.* 1671: London Bridge.
1676: *M.*
1694: granted a release on account of his infirmities (? about 64 years of age).

12. Verney, John.
1667; elected *S.* and, declining to serve, was fined £5.
1671. 10. 04: *M.*
1672. 05. 23: last date as *M.*
1703/4. 01. 13: *d.* before.

13. Twigg, Richard (No. 2), **1**'s son.
1670. 04. 07: elected Assistant in father's place.

14. Hawes, John, *Sp.M.* 1670: Chreechurch; 1672: Little Eastcheap.
1678. 11. 01: free, his son being about 21 years of age.

15. Haslom, Henry, 1670: St Clement's Danes.
1668: *A.* **36.**
1668/9. 01. 07: *M.* as proxy for **7.**
1675. 07. 01: *d.* before.

16. Howe (How), Joseph, 1670, 1695: Royal Exchange, Threadneedle Street.
1667/8: *A.* **35**; 1668: *A.* **37**; 1676/7: *A.* **50.**
1672. 10. 02: *M.*
1695. 04. 14: *M.* deputed by letter for **26.**
1695. 10. 02: *M.*
1667: see under **19.**
1674: elected *S.* and, declining to serve, was fined £5.

17. Goodman, Thomas, 1671: West Smithfield.
1677/8. 01. 10 to 1678. 06. 27: *M.*

18. Bolter (also Boulter), Hugh, 1672: Little Minories.
(1658): *A.* to ?.
1666. 11. 30; made free.
1671. 11. 09: fined £80 for selling thirty-six dozen frames without glasses.
1672. 05. 23: search made.

19. Clark (also Clarke), John, *Sp.M.* 1672: Leadenhall Street.
1667: fined for selling to **16** sixteen pairs of spectacles being looking-glass ground only on one side; arrested and referred by Lord Mayor back to the *Sp.C.* who mitigated the fine.
1669: fined for many bad spectacles.
1670. 10. 05: fined £3 for selling three pairs of looking-glass spectacles; said that **27** made them, but **27** denied it.
1668/9: *A.* **39**; (1692): *A.* **65.**

20. Hickett (also Hicketts), John, 1671: Aldersgate Street.
1658. 06. 30: *A.* for eight years.
1666. 10. 03: free.
1671: maker of bad spectacles fined £2. 3*s.* 2*d.* and turned over to him.
1682: *A.* **46** before.
1682. 10. 09; 1692. 11. 04: *M.*

21. King, Thomas (No. 1).
1669: *A.* **42**; 1674: *A.* **46** for seven years (as **46** was turned over to **20** before 1682, **21** must have been dead then).
1679. 06. 26: was probably alive as **42** was made free then.

22. Shield, Nicholas, *Sp.M.* 1667: Fenchurch Street.
1668. 04. 20: fined for making spectacles of looking-glass wrought on one side only; arrested and referred by Lord Mayor back to the *Sp.C.* who mitigated a fine of £18 to £6 by instalments.
1668. 09. 30: paid £3 in the Court who accepted it as full payment; promised not to offend again.
1670. 09. 16: very bad spectacles made by him were found at an haberdasher's shop.
1670. 10. 04: fined £2 for two pairs of spectacles made of looking-glass.
(1668): *A.* **29.**
1670. 10. 05: last entry.

23. Penny, John, *Sp.M.* 1670: Bishopsgate.
1667. 10. 02 to 1670. 03. 31: paid quarterage.
1670. 09. 21: six pairs of bad spectacles of his found at an haberdasher's shop were razed (scratched with a diamond).
1670. 10. 05: fined 7*s.* for making and selling one dozen bad spectacles.

II. Reeves (? identical with ix (after **61**)), 1659/60: spoken of by Pepys; telescope objective in the Science Museum signed John Reeves.

24. Aldridge, John, *Sp.M.* 1669: in the Minories.
1669. 05. 15: search made; had an apprentice not bound.

25. Briggs (also Brigge, Brigg), John, *Sp.M.* Shoe Lane.
1670. 03. 31: admitted free on the request of William, Earl of Craven as having served for the Restoration.
1674/5. 01. 14: elected *B.*
1669. 08. 08: ordered an indictment for next session against J. Briggs of St Bride's, gardener, that he uses the trade of spectacle making and grinding watch-glasses, not having served his years to the same trade as an apprentice.

26. Handford, Thomas, 1676: Leadenhall Street.
1676: search made.
1680; 1681. 06. 30; 1692. 07. 14: *M*.
1688. 06. 28: fined 1*s*. for not coming within one hour of being summoned.

27. Hill, John, 1672, 1676: St Paul's Churchyard.
1669. 05. 05: fined for many bad spectacles.
1670. 10. 05: see under **19**.
1683/4. 01. 12 to 1684. 03. 20: *M*.
1685. 09. 30: *d*. before.

28. Jenkinson, William (No. 1), **61**'s father, (? **2**'s son), 1669: Southwark.
1669. 05. 15: six pairs of bad spectacles made by him found at an haberdasher's shop.
1671: no bad spectacles found.
1692: last entry.

29. Yarwell, John, citizen and *Sp.M.*
1662. 12. 09: *A*.
1668. 04. 02: turned over to **22**.
1669: free.
1674: *A*. **45**; (1695): **70**.
1692. 04. 29: six pairs of leather frames taken from his shop; 4*d*. paid for search at his other shop.
1684. 10. 01: *M*.
1698: removed to "Archimedes & Crown."
1712: *d*.

30. Gardner, Henry.
1670. 10. 14: arrested for making and selling three pairs of bad spectacles and fined £3, afterwards reduced to £2.

31. Hatfield, William, *Sp.M.* 1671: Southwark.
(1663): *A*. to ?.
1670. 11. 06: free.
1671: search made.

iii. Baili (Bayley), *Sp.M.* 1663. 05. 15: St Paul's Churchyard (from Monconey's *Voyages*, Vol. ii, p. 18).

32. Hale, . . . , widow, 1675: Bishopsgate.
1675: search made.

33. Mathews, Jeremy, *Sp.M.* 1671: Jewen Street.
1671. 10. 04: fined £91. 10*s*. for making and selling one hundred and twenty-four pairs of bad spectacles found at various shops.
1696. 11. 01: *d*. about this time as his son was turned over then.

34. Tailor, Zachery, **4**'s son, 1675: Backside Exchange.
1664. 03. 31: *A*. to **4**.
1671. 10. 04: free.
1675: search made.

iv. Culpeper, Edward, xi's (after **88**) father.
1666: name on a sun-dial.

35. Longland, William, 1686: "The Ship" in Cornhill.
1667/8. 01. 27: *A*. to **16**.
1674. 07. 02: free.
1686: name on a parchment telescope in the Stuart Exhibition ("The Ship" in Cornhill Catalogue, p. 90).
1686. 10. 12; 1687. 10. 07: *M*. succeeded by **29**.
1694. 10. 03: *M*. succeeded by **9**.
1695. 06. 20: *M*. succeeded by **29**.
1722: *d*. probably after.

36. Tengay, Gregory, son of George Tengay of Ware, Herts, maltster.
1668. 04. 02: *A*. to **15**.
1675. 07. 01: free.
1679. 06. 04: paid fine of £2 (? for his first apprentice).

37. Gay, Thomas, son of Richard Gay, Warum, Northants, husbandman, 1723: at "The Archimedes and Spectacles," near the Sun Tavern behind the Royal Exchange (from an advertisement in Partridge's "Almanac" for 1723).
1668. 06. 25: *A*. to **16** for seven years.
1689/90. 01. 09: free.
1711: *A*. **90**; 1718: *A*. **102**.
1718. 10. 01 to 1720. 03. 31: *M*. succeeded in 1720. 10 by **62**.
(1732 if not 1739. 12. 27): still alive.

38. Turk, William, son of John Turk of Thornford, Dorsetshire, fisherman.
1668. 06. 25: *A*. to **9** for seven years.
1676/7. 01. 11: free.
1682. 10. 09: late servant of **9**.

39. Mayle, Thomas, son of Thomas Mayle of Godmanchester, Huntingdon, tobacco-pipe maker, 1675, 1695: Leadenhall Street.
1668/9. 01. 07: *A*. to **19**.
(1676): free.
(1701): *A*. **78**.
1697/8. 01. 13; ? 1731. 01. 13: *M*.
1736: last entry.

40. Tailor, John (No. 2), **4**'s son.
1669. 07. 08: *A*. to **4**.
1676. 10. 05: free.
1693: search made at Old Bethlem Gate, Moorfields.
1695: search made at Cheapside.
1696: last entry.

41. Throgmorton, James, **10**'s son, 1693: The Minories.
1669. 10. 06: *A*. to **10**.
(1676): free.
1677: *A*. 51.
1688/9. 01. 10; 1695/6. 01. 09; 1697. 04. 01: *M*.
1716. 10. 28: last entry.

42. STERROP, Thomas (No. 1), son of Ralph Sterrop of Worcester, clothier, 1693: Little Britain.
1669. 12: *A.* to **21**.
1679. 06. 26: free.
1692. 04. 14: see under **44**.
1693: search made.
1693: *A.* **67**.
1701/2. 01. 08; 1702. 03. 26: *M.*
1715: last entry.

v. MELLIN, John, latter end of seventeenth century, Abchurch Lane. Celebrated maker of microscopes.
1704: *d.* before.

43. FLOWER, Christopher, son of Thomas Flower of Burkington, Wiltshire, yeoman, 1693: Bishopsgate Street.
1655: *b.*
1671. 08. 15: employed by **5**, not *A.*
1671. 10. 04: *A.*
(1678): free.
1693. 10. 04: search made (he was dead then).

44. COCK (also Cocke, Cocks), Christopher, 1693: Long Acre.
1672: *A.* to ? before.
1680. 04. 07: admitted as a free member of the *Sp.C.*
1681. 06. 30: paid 13*s.* for his freedom.
1691. 06. 25: paid 2*s.* 6*d.* for apprenticing **62**.
1692. 04. 14: leather spectacles being objected to by the *Sp.C.* as unlawful, an innovation, and prejudicial to the trade, **44** and **42** being against it, Clerk in 1692. 11. 04 ordered to consult Counsel as to advisability of taking action.
1694. 10. 16: member of commission for publishing re interlopers.
(1687): *A.* **60**; 1691: *A.* **62**.
1695/6: last entry.

45. COLETHORP, Martin, son of H. Colethorp, Isle of Man.
1674. 05. 25: *A.* to **27**.

46. MANN, James (No. 1), son of John Mann of Burton, Hertfordshire, tailor, 1693: St Martin's; 1695: Angel Street.
1674. 11. 05: *A.* to **21** for seven years; turned over to **20**.
1682. 03. 30: made free; paid 13*s.* 6*d.*
1695. 01. 20: fined for making and selling thirty-one pairs of white spectacles ground only on one side, and five pairs of black spectacles, being unlawful and bad wares.
1697: expelled and disowned as an assistant for selling a great quantity of improper wares, viz. frames without glasses, to persons not freemen.
1702/3. 01. 07: the *Sp.C.* having rescinded their decision, it was ordered that frames without glasses may be sold without action being taken; **46** reinstated as Assistant.
1716/7. 01. 10; 1717. 03. 28: *M.*

47. HASLOM, . . ., **15**'s widow, owned firm from 1675. 07. 01; see under **36**.

48. STEVENS, Samuel, 1683: St Clement's.
(1675): *A.* to ?.
1682/3. 01. 11: free.
1683: search made.
1708. 10. 06: last entry.

49. HARRIS, John.
(1676): *A.* to **4**.
1683. 10. 03: free.
1703. 10. 06: fined £3. 1*s.* for being in arrears with his quarterage; fine mitigated to £1. 10*s.*

50. SPRAT, John, son of John Sprat of St Andreas, Holborn.
1676/7. 02. 08: *A.* to **16**.

51. STERROP, Richard, **42**'s brother.
1677. 06. 28: *A.* to **41**.

52. STERROP, Ralph, grandson of Ralph Sterrop, son of Thomas Sterrop of Worcester, both clothiers, 1695: St Paul's Churchyard.
(1678): *A.* to ?.
1685. 09. 30: paid 13*s.* 4*d.* for his freedom.
1693: *A.* **69**: 1702: *A.* **77** and **80**; 1706: *A.* **82**; 1709: *A.* **86**; 1729: *A.* **128**.
1692. 04. 29: two pairs of spectacles in leather frames taken from his shop.
1695. 04. 09: search made.
1695: unanimously ordered by the *Sp.C.* that some action be taken against him as he kept two apprentices. Promised to give an answer in a week's time.
1695. 02. 08: said he would keep the apprentices; Court of assistants ordered that speedy action be taken against him.
1702. 09. 30; 1705/6. 01. 10: *M.*
1734: last entry.

53. COLE, Joseph, 1693: St Martins.
(1678): *A.*
1686/7. 01. 18: free.
1711/2. 01. 08; 1713; 1714: *M.*
1715: *M.* succeeded by **56**.
1715. 03. 31: still alive.

54. BEMBRICK (also Bombrook, Bombrooke, Bambreth), William (No. 1), **103**'s father, 1693: behind Exchange, Cornhill; 1695: Cornhill, also Threadneedle Street.
1693. 08. 03: search made.
1695. 04. 09: search made; four pairs of black spectacles taken.
1718: *A.* **103** and **104**.
1709. 10. 14; 1711/2. 01. 17: *M.*
1723. 10. 18: last entry.
1725. 10. 06: probably alive; see under **103**.

55. Hales (also Hale, Hailes), Thomas (No. 1) (? identical with x (after **62**)), possibly **32**'s son, 1693: St Paul's Churchyard.
(1680): *A.* to ?.
1687. 03. 31: free.
1693; 1695. 04. 09: searches made.

vi. Boyse, William, 1681: at the "Golden Griffin" in Belle Sauvage, Ludgate Hill. The only English operator in glass; advertised artificial eyes made in enamel burnt in without paint or lead (from H. Colley's *Starry Messenger*).

56. Saunders, William (No. 1) (? identical with **74**), *Sp.M.*
(1682): *A.* to ?.
1689/90. 01. 08: free.
1715/6. 01. 12: *M.*
1716/7. 01. 10: *M.* succeeded by **46**.

57. Sterrop, Thomas (No. 2) (? identical with **76**), 1683. 12. 12: first entry.
(1701): *A.* **76**; 1726/7: *A.* **122** (£18).
1734. 06. 24: may have been alive; see under **122**.

58. Cooberow (also Cowperow, Cooperoe), Mathew (No. 1), **105**'s father, 1695: Angel Street.
(1683): *A.* to ?.
1690. 10. 01: free.
1699: *A.* **73**; (1709): *A.* **87**; (1713): *A.* **92**.

59. Moore, Samuel, 1693: Ratcliffe Highway.
1693: search made.

60. Brewin, Thomas.
(1687): *A.* to **44**.
1694. 10. 16: free.

vii. Cox (Cock), John (No. 1) (? **44**'s son), 1693. 08. 15: Long Acre. Neither he nor John Marshall or any other not being a member shall for the future be employed by the *Sp.M.* in grinding convex or concave glasses.

viii. Marshall, John, first date 1687/8 (see First Paper on the Court Collection, *Trans. Opt. Soc.* **30**, 1928–9 (1)); 1688/9: Ludgate Street (under the sign of "The Gun"); 1693: St Paul's Churchyard.
1688/9. 02: first advertisement of the use of microscopes in medicine.
1692. 04. 29: shop searched, nothing found; paid 4*d.*
1695. 04. 09: another search; eight pairs of white and three pairs of black spectacles condemned; refused to say who the maker was.
1695. 05. 10: added to an advertisement "The like are sold by John Cox (vii (after **60**)), Prospective Glass Grinder at the 'Cock & Garter' in Long Acre." Regarding Prospect Glasses (four dozen) imported from Holland, John Houghton, F.R.S., in *A Collection of Papers for the Improvement of Trade*, etc., No. 197, 1696, says: "The four dozen Prospect Glasses account to nothing worth speaking about and they are of the mean sort. For Mr Yarwell (**29**) in St Paul's Churchyard and Mr Marshall (viii) in Ludgate Street and divers others have brought the art to such perfection as that I do not doubt but for good ones they 'ill vie with the best Foreign workmen."
1696. 03. 10: advertisement in the London Almanac: Microscopes after Leeuwenhoek, double Microscopes (compound) and three Power Prospect Glasses (with a revolving disc).
1720. 09. 17: advertisement in Daily Cour. of John Marshall, Optician to His Majesty at the "Archimedes," Ludgate Street, London: "Makes spectacles marked on the frames with the age as some people aged 30 take glasses for 60 and 70. He does this so as to prevent mistakes as many people have injured their sight by buying the wrong spectacles. Also makes and sells microscopes, telescopes & spectacles made of Rock Crystal." Two telescopes of his in the Court Collection, Science Museum.

61. Jenkinson, William (No. 2), **28**'s son.
(1689): *A.* to ?.
1696. 03. 26: free.

ix. Reeves, John (? identical with ii (after **23**)), 1689: convex lenses for illuminating purposes.

62. Scarlett, Edward (No. 1), **97**'s father, 1705: "Archimedes and the Globe" in Dean Street, near St Anne's Church, Soho (all his life here).
1691. 06. 25: *A.* to **44**.
1704/5. 01. 18: ordered that Mr John Throgmorton (**10**) and Mr E. Scarlett being bound to the Company and using this trade should forthwith take up their freedom; if they refused to do so, they should be sued.
1705. 06. 28: free.
1716/7: *A.* **97**; 1730: *A.* **131** (£21).
1720. 10. 05 to 1722. 10. 03: *M.* succeeded by **70**.
1743: *d.*

x. Hailes, Thomas (No. 2) (? identical with **55**), 1692: at the "Telescope and Spectacles" against the North Gate, St Paul's Churchyard.

63. Bourne, Jane, **3**'s widow, 1693: at Holbourne; 1695: Middle Row at Holbourne.
1691. 09. 20: paid quarterage up to.
1693. 08. 15; 1695. 04. 09: searches made.

64. Howe, John (No. 1), **116**'s father, son of Joseph Howe.
1699. 03. 30: admitted free by patrimony.
1725: *A.* **117**.
1710. 05. 17: excused from Wardenship and Mastership for £2. 2*s.* or what Mr Sanders can get, he living 10 miles from London.
1728. 10. 02: ordered to take action in connexion with assistants not appearing at Court (except **64** and **73**).
1733. 03. 29: both his sons free; **64** *d.* probably after. An old refracting telescope of his in the Science Museum.

65. Clarke (Clark), Lucretia.
1699: free by patrimony.

66. Combs (also Coombs, Coombe), Oliver, 1693: Leadenhall Street.
1727. 06. 29: differences with the Court.
1727/8. 01. 11: admitted as a foreign brother and sworn as a freeman.
1742. 10. 06: summoned for arrears of quarterage and gave a note of hand to **90**.

67. Johnson, John.
1693. 06. 20: *A.* to **42**.
1700/1. 01. 09: free.
1726: *A.* **120**; 1733/4: **130**.
1736. 12. 30: ordered that **67**, being in reduced circumstances having received charity money from the Company, be dismissed from the Court of Assistants.

68. Flower, Mary, **43**'s widow, 1693: Bishopsgate Street.
1693. 10. 04: first mentioned.
1697. 06. 01: last entry.

69. Brandreth, Timothy, till about 1712 in company with **70**, 1706: "Archimedes and Globe" in Ludgate Street.
1693. 10. 23: *A.* to **52**.
1701. 06. 26: free.
(1714): *A.* **94** (*N.C.*).

70. Willdey, George, 1712: toy shop next the Dog Tavern, Ludgate Street.
(1695): *A.* to **29**.
1702. 03. 26: free.
1706. 06. 27: fee of £2 for taking his first apprentice.
1706: see under **69**.
1706: *A.* ?; 1717: *A.* **98**; 1727: *A.* **125**.
1722. 10. 03: *M.*
1733: *M.* succeeded by **79**.

71. Burbidge (also Burbridge), Isaac (No. 1), **108**'s father.
1719: *A.* **108**.
1717. 10. 02 to 1718. 10. 01: *M.* succeeded by **37**.
1720/1. 01. 29: *d.* before, when **83** was elected Assistant in place of I. Burbidge, deceased.

72. Verney, Phillip, **12**'s son, late citizen and *Sp.M.*
(1696/7): *A.* to ?.
1703/4. 01. 13: free.

73. Mann, James (No. 2) (? identical with **129**), son of James Mann of Christchurch, *Sp.M.*, 1735: "Archimedes and Two Pairs of Golden Spectacles" near the Castle Tavern, Fleet Street.
1699. 04. 04: *A.* to **58**.
1706/7. 01. 06: tried to obtain his freedom of the City in the Turners' Company, was refused and told to take it at the *Sp.C.*
1707. 03. 27: order to arrest him for filling and using the trade of *Sp.M.* within the City, not being free of the same nor of the *Sp.C.*
1707. 06. 28: made free; paid £1. 14*s.* 4*d.*
1707. 07. 03: to be discharged from all prosecution, paid £5. 5*s.*
(1711): *A.* **89**; 1722: *A.* **110**; 1725: *A.* **115**; 1732: *A.* **135** (£21); 1738: *A.* **143** (£21).
1725: *M.*
1737. 10. 05: *M.* succeeded by **94**.
1725. 04. 01: ordered that he should be excused from serving as *M.* upon paying a fine of £2. 2*s.*

74. Saunders, William (No. 2) (? identical with **56**).
(1706): probably free then as his apprentice **83** was made free on 1714. 07. 01.
(1707): *A.* **83**.

75. Pateshall, Thomas, jun., **23**'s son, late citizen and *Sp.M.* 1706. 06. 26: free by patrimony.

76. Sterrup, Thomas (? identical with **57**).
(1701): *A.* to ?.
1708. 04. 01: free.
1718. 05. 26: *A.* **101**.
(1725): may have been alive then; *d.* before 1725. 07. 03.
1730: his son **132** *A.* to his widow **118**.

77. Roak, Joseph.
1701. 07. 01: free (? *A.* to) and afterwards turned over to **52**.
1709. 06. 30: free, having been *A.* to **52**.

78. Hatfield, Thomas (? **31**'s son).
(1701): *A.* to **39**.
1708. 10. 06: free.

78. Hatfield, Thomas (*contd.*)
1744 to 1750: received money from **29**'s legacy.
1751: and afterwards, his widow received money from **29**'s legacy.

79. Archer, Thomas.
(1701): *A.*
1708/9. 01. 13: free.
1717/8: *A.* **100**; (1720): *A.* **108**; 1727: *A.* **123**.
1733. 10. 03 to 1734. 10. 02: *M.* succeeded by **81**.

80. Roak, Richard (? **77**'s brother).
(1702): *A.* to **52**.
1709. 10. 06: free.
1728 to 1739: *B.* (from a remark on the front page of the Minute book for 1695 to 1735); his address was Hand Alley, Bishopsgate Street in the Coach Yard.
1739. 10. 04: ordered that the Upper Warden should provide a handsome great coat trimmed with gold lace and likewise a hat trimmed with lace ready for the next Court, also a bag for the Company's books.
1742. 09. 30: received money from **29**'s legacy.
1743. 03. 31: **124** appointed *B.* to replace **80** deceased.
1748. 10. 05: his widow received money from **29**'s legacy.

81. Flower, John, **43**'s son.
1712. 10. 24: free by patrimony.
1734: *A.* ? (£20).
1735. 10. 01: *M.* succeeded by **73**.
1757. 10: last entry.

82. Bass, George, 1733: Bridewell Precinct; 1764: Fleet Ditch.
1706. 06. 27: *A.* to **52**.
1716. 03. 28: free.
1728: *A.* **126**; 1733: *A.* **136** (£10. 10*s.*); 1742: *A.* **148**.
1747. 10. 01: *M.* succeeded by **110**.
1754: replaced...?. According to the article of "Veritas" he played an important rôle in the C. M. Hall versus J. Dollond affair; he also signed the petition of 1764.
1768. 10. 05: last entry; *d.* probably before the spring of 1769.

83. Adams, John.
(1707): *A.* to **74**.
1714. 07. 01: free.
1720: *A.* **109**, turned over to him for the rest of his term.
1720. 01. 12: elected Assistant in place of **71** deceased.
1738. 12. 28: last entry.
1721. 07. 13: he and another were removed from their posts because they had gone to persons selling spectacles with the design of taking names and places of abode; this was against the rules, as only the *W.* and *B.* could do it.

84. Sterrop, Jane.
(1708): *A.* to ?.
(1715): probably free, as her apprentice **85** was made free on 1716. 10. 03.

85. Day, John.
(1709): *A.* to **84**.
1716. 10. 04: free.
(1724): *A.* **119**.
1736: *d.* probably.

86. Johnson, Robert.
(1709): *A.* to **52**.
1716. 10. 03: free.
1742. 10. 06: last entry.

87. Lincoln, Thomas, 1749/50: at St Bartholomew's the Less.
(1709): *A.* to **58**.
1716. 10. 03: free.
1719: *A.* **99**; 1724: *A.* **112**; 1726: *A.* **102** and **121**; (1727): *A.* **124**; 1739: *A.* **144** (£5); 1745: *A.* **151** (£10); 1749/50: *A.* **159** (natural love and affection) and **158** (*G.W.*); 1753: *A.* **322** (*G.W.*).
1738. 06. 29: paid a fine of £1. 1*s.* for keeping a boy at work under age and unbound, and he should bind him (probably **144**) in a year's time.
1754. 10. 03: same fine for same offence (possibly referring to **171**).
1746. 10. 02 to 1747. 10. 01: *M.* succeeded by **82**.

88. Jones, William (No. 1), son of Lewis Jones of the parish of St James', Westminster, coachman.
1709. 10. 06: *A.* to **62**.
1721. 10. 04: free.
(1719): ? *A.* **106**.
1726. 07. 02: last entry.

xi. Culpeper, Edmund, iv's (after **34**) son, 1710: "Cross Daggers" in Moor-Fields. Telescopes for Coelestial Observations; Telescopes for the Pocket: Perspective-Glasses of all sorts; 1725: Black-White House, Middle Moor-Fields & (a second shop) Under the Piazza of the Royal Exchange.
1738: last date.

89. Woodroffe, Thomas.
(1711): *A.* to **73**.
1718. 03. 27: free.
1742. 09. 30: received £1. 10*s.* from **29**'s legacy.

90. LOFT, Mathew, son of Mathew Loft, Lambeth, waterman.
1711. 08. 15: *A.* to **37**.
1720/1. 01. 12: free.
1725: *A.* **114** and **168**; 1728: *A.* **113**; 1736: *A.* **139** (£20); 1741/2: *A.* **147**.
1724. 03. 26: allowed to take **114** a year before he was bound and had to pay a fine of £1. 1*s.*; for his first *A.* he paid £2.
1742. 10. 03: *M.* but very ill up to 1744. 10. 04 and incapable of attending.
1744. 12. 27: sworn as *M.*
1745. 10. 02: last appearance as *M.*, **97** chosen in his place.
1747. 12: probably *d.* (see under **147**).

91. SAUNDERS, Robert, **56**'s son, citizen and *Sp.M.* of London.
1720. 06. 30: free by patrimony.
1743. 03. 31: *d.* before; **97** replaced him as Upper Warden.

92. RADFORD, William.
(1713): *A.* to **58**.
1720. 06. 30: free.
1724/5. 01. 27: chosen Assistant and fined £10 for contempt.
1725. 04. 15: admitted and the fine remitted to £1. 10*s.* and £2. 2*s.* charges of Court and Clerk.
1738: last date as Assistant.

93. BURBIDGE, Esther, **136**'s daughter.
(1714): *A.* to ?.
1721/2. 01. 11: free.

94. WARD, John.
(1714): *A.* to **69** (*N.C.*).
1721/2. 01. 11: free.
1737. 10. 05 to 1744. 10: *M.*
1755. 10. 02: his widow received money from **29**'s legacy.

95. HAREBOTTLE, Untow.
(1715): *A.* to ?.
1722. 04. 23: free.

96. MANN, John, **73**'s son, citizen and *Sp.M.*
1723/4. 01. 09: free by patrimony.

97. SCARLETT, Edward (No. 2), **62**'s son, 1749: Maxwell Street (Poll of the citizens for 1749).
1716/7. 01. 10: *A.* to his father **62**.
1724. 06. 25: free.
1738: made the original reflecting microscope for Baker (*Phil. Trans.* No. 442, July 1736, p. 259).
1743. 03. 31: see under **13**.
1745. 10. 03 to 1746. 03. 27: *M.*
1779. 10. 06: *d.* before.

98. WATKINS, Edward, son of Thomas Watkins of Linton, Kent, yeoman.
1717. 08. 29: *A.* to **70**.
1724/5. 01. 07: free.

99. HALIBURTON, Andrew.
(1717): *A.*
1719. 03. 18: turned over to **87**.
1724. 06. 25: free.

100. LINNELL, Elijah, son of Robert Linnell, citizen and tallow chandler of London.
1717/8. 03. 11: *A.* to **79**.
1725. 07. 01: free.
1750. 10. 04: received 10*s.* from **29**'s legacy.
1754. 10. 03: *d.* at St Giles, Cripplegate.

101. PHIPPS, John, son of Joseph Phipps, Shoreditch, butcher.
1718. 05. 26: *A.* to **76**.
(1725): free.
1729: *A.* **127**; 1736: *A.* **141** (£157. 10*s.*) and **106**.
1739. 10. 04: after being excused from acting as *W.* or *M.* paid a fine of £10.
1752. 10. 04: ordered that he be excused from fine, as he lives in the country.
1757. 12. 27: retired to the country and left all manner of business; now infirm at 55 years of age, asked to be relieved of all responsibility and not to pay quarterage; agreed, if he paid a fee of £2. 15*s.* 6*d.*

102. EASTLAND, William (No. 1), 1764: Clerkenwell.
1718. 10. 03: *A.* to **37**.
1726. 03. 31: free, having been turned over to **87**.
1737. 05. 03: sworn Assistant (having refused before); promised to pay fine and gave two notes of hand £4. 13*s.* 3*d.* (1737. 09. 29) and £6. 1*s.* (1737. 12. 25).
1764: signed the petition against **155**.
1768. 03. 31: last entry.
(1761): *A.* **182**.

103. BEMBRICK, William (No. 2), **54**'s son.
(1718): *A.* to **54**.
1725. 10. 06: free.
1748. 10. 05 to 1754: received money from **29**'s legacy.

104. BEMBRICK, Isaiah, son of Richard Bembrick, cordweyner.
1718. 10. 30: *A.* to **54**.

105. COOBEROW (also Coopero), Mathew (No. 2), **58**'s son.
(1718): *A.* to ?.
1725. 04. 01: free by patrimony.

106. FORD, Henry.
(1719): *A.*
1726. 03. 31: free.

107. BROWN, Samuel.
(1719): *A.* to ?.
1726/7. 01. 12: free.
1732. 10. 04: fined for arrears of quarterage 10*s.* as a forfeit and £2. 14*s.* costs, which he paid.

108. BURBIDGE, Isaac (sometimes Joseph) (No. 2), **71**'s son.
1719. 11. 30: *A.* to **71**.
(1720): turned over to **79**.
1727. 06. 29: free.

109. JOHNSON, Isaac, **67**'s son.
1720. 08. 10: turned over to **83**.
1727. 03. 30: free (made his mark, not knowing how to write).

XII. HEATH, Thomas, 1721 and 1738: "The Hercules-Globe" next door to the Fountain Tavern in the Strand (trade card).

110. CUFF (also Cuffe), John, son of Peter Cuff of London, citizen and broiderer.
1722. 04. 13: *A.* to **73** for seven years.
1729/30. 01. 08: free.
1731: *A.* **133** (£10. 10*s.*); 1744: *A.* **149** (£30. 15*s.*); 1746/7: *A.* **153** (£30. 15*s.*); 1755: *A.* **169**; 1765: *A.* **191** (*N.C.*).
1745. 10. 03: he alleged that he would be obliged to part with one of his apprentices (the only one we know of at this time was **149**) and applied to take another without fine. (Agreed but the usual fine.)
1748. 10. 05 to 1749. 10. 04: *M.*
1770. 03. 29: at his own request was discharged from position of Assistant.

111. ADAMS, Nathaniel, son of Nathaniel Adams of St Ann's, Westminster, glover, 1737: at "The Golden Spectacles," Charing Cross.
1722. 11. 28: *A.* to **62** for seven years.
1730. 03. 06: free.
1735 (*c.*): Optician to the Prince of Wales.
1737: *A.* **142** (£21); before 1743: *A.* **137**.
1743. 12. 29: *d.* before.

XIII. MARTIN, Benjamin (*b.* 1704, *d.* 1782). According to the book *Speculum Hartwellium* he made a fluid object glass for a telescope.
1764: opposed **155**'s Patent. Gabriel Wright worked for him.

112. COX, John (No. 2).
1724. 09. 30: *A.* to **87**.
1732. 06. 29: free.
(1743): *A.* **137** without the fee of £2.

113. DEANE, David, son of Richard Deane of Chatham, 1764: Smithfield.
(1724): mariner.
1728. 11. 06: *A.* (? turned over) to **90**.
1731. 10. 01: free.
1760. 10. 01 to 1761. 09. 30: *M.* succeeded by **119**.
1764: signed the petition against **155**.
1773. 07. 01: accepted the office of quarterage collection instead of **114**.
1777: last entry.

114. TOMLINSON, James.
1725. 03. 25: *A.* to **90**.
1739. 03. 29: free.
1748. 10. 06: paid fine of £5 for not being a free *Sp.M.*, and became one.
1749. 10. 05: chosen Assistant with **142** and **147**.
1764. 03. 24: shall have 4*s.* in the pound of all the quarterage money collected by him.
1746: *A.* **152** (£3. 3*s.*); 1751: *A.* **162** (£4); 1755: *A.* **168** (*G.W.*); 1758: *A.* **174**.
1756. 07. 01: allowed to learn his nephew...(whom he had taken out of charity) spectacle making, though he had two apprentices till they are free on Lady day (04. 09).
1757. 06. 30: allowed to have another apprentice in place of a runaway one.
1758: fine of £4. 4*s.*
1764. 10. 03 to 1769. 10. 05: *M.* succeeded by **147**.
1773. 07. 01: resigned office of quarterage collection from foreign members and received thanks for his work; **113** elected in his place.

115. SCATLIFF, Samuel, son of Simon Scatliff of Wapping, ship chandler; Spectacle and optic glass maker, Friar Bacon's Head, corner of St Michael's Alley; 1764: St Paul's Churchyard.
1725. 04. 29: *A.* to **73**.
1734. 10. 02: free.
1737: *A.* **133** incapacitated; 1749: *A.* **157**; (1758): *A.* **175**.
1737. 10. 06: was allowed to take another apprentice in lieu of **133** on payment of a fine of £30 to ensure that **133** did not work for him again.
1751. 10. 05 to 1752. 10: *M.* succeeded by **135**.
1764: signed the petition against **155**.

116. HOWE, John (No. 2), **64**'s son, citizen and *Sp.M.*, London.
1725. 05. 03: *A.* to **64**.
1733. 03. 29: free.
(1761): *A.* ? **183**.
1749. 10. 04 to 1750. 10. 23: *M.* replaced by **132**.
1744: *d.* probably.

117. HOWE, Robert, **64**'s son.
1725. 08. 03: *A.* to **64**.
1733. 03. 29: free.
1749. 03. 30: went abroad.

118. STERROP, Mary, **76**'s widow and **132**'s mother; widowed after (1725) (see **101**) and before 1730. 07. 03 (see **132**).
1730: *A.* **132**; 1760: *A.* **167**.

119. EGLINTON (also Eaglinton), Peter (No. 1), **179**'s father.
(1726): *A.* to **85**.
1733. 04. 01: free.
1736: *A.* **140** (*G.W.*); 1760: *A.* **179** (2*s.* 6*d.*).
1761. 09. 30: *M.*
1763. 10. 05: *M.* succeeded by **142**.

120. SPITTELL, John (? identical with **124**).
1726. 07. 01: *A.* to **67**.
1734. 10. 02: free.

121. RICHARDSON, Richard (No. 1), son of Richard Richardson of London, a carman.
1726. 09. 21: *A.* to **87**.
1734. 10. 02: free.
1738. 03. 30: last entry.

122. RIBRIGHT (Ribwright), Thomas (No. 1), son of Robert Ribright of Cambridge, cordwainer (*b.* probably 1712, *d.* probably 1781), before 1764: "Golden Spectacles" at the Poultry.
1726/7. 03. 14: *A.* to **57** (£18).
1734. 06. 24: free.
1741: *A.* **145**.
1736. 12. 30: ordered, having paid the fine of £3, he may take a second apprentice.
1741. 03. 28: ...having run away, he may, after a fine, take over **145**.
1758. 10. 04; 1760. 10. 01: *M.*

123. ARCHER, Joseph, **74**'s son.
1727. 03. 30: *A.* to **79**.
1734. 06. 29: free.

124. SPILLETT, John (No. 1) (? identical with **120**).
(1727): *A.* to **87**.
1734. 10. 02: free.
1743. 03. 31: appointed *B.* instead of **80**.
1772. 06. 25: *d.* shortly before.

125. PASSEVANT, Susannah.
1727/8. 01. 03: *A.* to **70**.

126. DRAKEFORD (also Drakefield), David, 1764: Fleet Ditch.
1728. 09. 16: *A.* to **82**.
1736. 07. 04: free.
1764: signed the petition against **155**.

127. MORRIS, John (No. 1).
1729. 06. 27: *A.* to **101**.
1736. 07. 01: free.
(1741): *A.* **146**; 1749: *A.* **156** (£100).
1754. 10. 07: *M.*, *d.* before his time was out, succeeded by **82**.

128. HURT, Joseph, son of William Hurt, late citizen and stationer.
1729. 08. 05: *A.* to **52**; several instruments of his (**128**) known.
(1736): free.

129. MANN, James (No. 3), (? identical with **73**), citizen and *Sp.M.*, 1736: Sir Isaac Newton's Head at St Paul's Churchyard; 1743, 1751: "Sir Isaac Newton's Head" and "Two Pair of Golden Spectacles."
(1729): *A.* to ?.
1743: before, Ayscough & Mann.
1747. 03. 12: Ayscough & Mann.
1751: last entry.

130. ADEY, Josiah.
1733/4. 01. 10: turned over to **67**.

131. RICHARDSON, Mathew, son of Richardson of St Clements Danes, coffeeman.
1730. 06. 10: *A.* to **62** (£21).
1737. 12. 27: free.
1742. 10. 06: summoned to pay arrears.
1752. 10. 05: a Mrs Ann Richardson, probably his widow, received money from **29**'s legacy.

132. STERROP, George, **76**'s and **118**'s son, St Paul's Churchyard.
1730. 07. 03: *A.* to **118**.
1737: free.
1747: *A.* **154**.
1754. 10. 03: paid fine of £1 for employing a youth one year before his time.
1756: *d.* between 04. 28 and 05. 19.

133. PORTER, John.
1731. 10. 06: *A.* to **110** (£10. 10*s.*).
1737. 05. 06: turned over to **115**.
1737. 10. 06: declared incapacitated (see **115**).

134. WILLDEY, Thomas, **70**'s son.
(1732): *A.* to ?.
1739. 10. 04: admitted by patrimony.

135. AYSCOUGH, James, son of James Ayscough of Highworth, Wiltshire, clerk (clergyman).
1732/3. 03. 10: *A.* to **73** (£21).
1740. 03. 27: free.
1752: *M.*
1753: *M.* succeeded by **127**.
1743 to 1747. 03. 12 in company with **73**.

136. BYGRAVE, Richard.
1733. 03. 27: *A.* to **82** (£10. 10*s.*).
1741/2. 02. 28: free.

XIV. Short, Thomas, XV's brother, maker of reflecting telescopes; only one specimen known—in the Court Collection, Science Museum, signed "3″ Gregor. Tel. 12 = 257"; no top figure.

XV. Short, James, XIV's brother (*d.* 1768. 06. 15), 1763 Mortimer's Directory: Surrey Street. He died worth £20,000.

137. Marges, John, son of Jacob Marges, of the Parish of St Martin's in the Field, goldsmith.
(1735): *A.* to **111**.
1743 (?). 12. 29: turned over to **112**.
1742. 12. 30: free.
1758. 04. 04: bankrupt: St Martin's in the Field.

138. Whitford, Thomas.
(1736): *A.* to ?.
1743. 06. 30: as foreign brother admitted and sworn a freeman.
1792. 06. 28: *d.* soon before.

139. Lecour, James (No. 1).
1736. 07. 29: *A.* to **90** (£20).
1743. 10. 06: free.
1761: Deans Street, Fetter Lane: sold distorted pictures, to be used with mirrors.

140. Eglinton, John, son of ..., citizen and *Sp.M.*
1736. 09. 30: *A.* to **119** (*G.W.*).
1745. 10. 03: free.

XVI. Chaplain, ..., London, 1736. 12. 16. His reflecting telescopes mentioned by Dr Bevis together with those of William Molyneux, **97**, XV (after **136**), and **73**.

141. Stokes, William.
1736. 12. 21: *A.* to **101** (£157. 10*s.*).
1743. 12. 30: free.

142. Watkins, Francis (No. 1), son of Jeremy Watkins of the Parish of New Church in the County of Radnor.
1737. 08. 18: *A.* to **111** (£21).
1746. 03. 27: free.
1749. 10. 05: see under **114**; in the Poll of City of Westminster.
1750: *A.* **160** (£42); 1753: *A.* **164** (£42).
1763. 10. 05 to 1764. 10. 03: *M.* succeeded by **114**.
1774. 03. 31: **97** and **142** not attending their summons, the Clerk is ordered to wait upon them with an account of their arrears of quarterage due to the Company.
1781. 03. 29: Mr Watkins having not attended the several Courts since 1769 and being much in arrears for fines and quarterage, ordered that the Clerk consult Mr King of Cutler's Hall concerning the powers of this Court to oblige the said Mr Watkins to attend; and what mode to adopt to compel him to pay the arrears.
1782. 03. 28: Mr King being asked whether for arrears forfeits could be collected from a member living out of the city replied in the affirmative. Ordered that the following bill of dues from Mr Watkins of Charing Cross be transmitted to him and upon his refusal to discharge it Mr King sue him for the same.
1782. 03. 30: To fines for no attendance at 5 different courts held from Michaelmas 1764 to Lady Day (March) 1782 at 1*s.* each as directed by the By Laws of the C^{y} viz. 17 years and ½ at 5*s.* per annum: £4. 7*s.*; To quarterage from Michaelmas 1767 to Lady Day 1782 at 4*s.* per ann. viz. 14½ years £2. 18*s.*; total £7. 5*s.*

143. Johnson, Samuel, son of Abraham Johnson of Westram, Kent, carpenter, 1763 Morimer's Directory: Ludgate Street.
1738. 06. 12: *A.* to **73** (£21).
1745. 10. 03: free.
1772. 03. 26: *d.* just before; see **155** under this date.

XVII. Gilbert, John, 1738: reference in a tract describing Hadley's quadrant; 1763 Mortimer's Directory: Tower Hill; 1776 Mortimer's Directory: 23, St Paul's Churchyard (if the same); 1791: 8, Postern Row, Tower Hill.

XVIII. Adams, George (No. 1), XXV's (after **187**) and XXXII's (after **227**) father (*b.* ?, *d.* 1773, according to his son's (XXXII (after **227**)) edition of G. Adam's *Treatise on the Globe*..., preface), 1741. 11. 20: corner of Raquet Court, Fleet Street; sign "Tycho Brahe's Head."
1735: earliest date.

144. Nott, William.
1739. 04. 04: *A.* to **87** (£5).

145. Spurrier, Aaron.
1741: before *A.*
1741. 03. 28: turned over to **122**.

146. Chapman, Charles.
(1741): *A.* to **127**.
1748. 03. 31: free.

147. Nairne, Edward, son of Edward Nairne (*b.* 1726, *d.* 1806).

1741/2. 02. 19: *A.* to **90**.

1748. 03. 31: as he had at his master's death one year and two months to serve, he applied to the Lord Mayor and Aldermen and obtained an order of 1747/8. 01. 26 admitting him to the freedom of the City by redemption in this Company. Whereupon he was admitted and sworn a free *Sp.M.*

1749. 12. 28: ordered that the £2. 2*s.* formerly paid by him as a fine on admittance to the Company shall be deducted from the £5 due for his fine when admitted as assistant by reason only that they called him so early after taking up his freedom. He paid £2. 18*s.*, making £5 with the £2. 2*s.* allowed.

1752: *A.* **163**; 1760: *A.* **180** (*N.C.*); 1764: *A.* **189** (£21); 1769: *A.* **197**; 1779: *A.* **213** (£150); (1788): *A.* **224** (£200); (1789): *A.* **225**.

1751. 06: paid £1. 1*s.* for keeping **163** one year before binding him as *A.*

1759. 03. 29: same with regard to **180**.

1769. 10. 04; 1774. 10. 05; and 1796. 10. 03 to 1797. 10. 03: *M.* succeeded by **155**. Nairne & Blunt 1791 Directory: 20, Cornhill.

148. Clark, Mathew.

1742. 09. 30: *A.* to **82**.

1752. 10. 05: free.

149. Kennett, James, son of Roger Kennett of Faversham, Kent, gentleman.

1744. 06. 28: *A.* to **110** (£31. 10*s.*).

150. Ribright, George, 1764, 1790: The Poultry.

(1744): *A.* to ?.

1751. 10. 03: as foreign brother admitted free.

1768: *A.* **196**; (1775): *A.* **206**.

1764: opposed **155**'s Patent.

1783. 10. 02: *d.* before.

151. Stedwell, John.

1745. 06. 27: *A.* to **87** (£10).

1752. 10. 05: free.

XIX. Hill, Nathaniel, 1746, 1754: first dates; 1763 Mortimer's Directory: "Sun & Globe," Chancery Lane.

1764: opposed **155**'s Patent.

152. Watkins, Thomas, son of John Watkins, deceased.

1746. 10. 02: *A.* to **114** (£3. 3*s.*).

153. Shuttleworth, Henry Raynes, son of William Shuttleworth of Wortonaby in the County of Leicester, grazier; 1791 Directory: 23, Ludgate Street and also "The Old Mathematical Instrument Shop" near West End of St Paul's.

1746/7. 02. 03: *A.* to **110** (£31. 10*s.*).

(1754): free.

1760. 10. 02: had to pay a fine of £2 for his first apprentice.

1761: **169** turned over; 1762: **182** turned over; 1769: **191** turned over; 1771: *A.* **200** (£10); (1790): *A.* **226**.

1782. 10 to 1787. 10: *M.*

1797. 10. 05: last entry.

154. Walker, Ralph.

1747. 10. 01: *A.* to **132**.

XX. Dollond, John (No. 1), F.R.S. (*b.* in Spitalfields 1706. 06. 10, *d.* 1761. 11. 30), **155**'s father. Originally a silk weaver, *c.* 1758 was associated with his son Peter Dollond (**155**) as an optician; made public Chester Moore Hall's invention of the achromatic object glass, invented a micrometer, and made many improvements to optical instruments; received the Copley Medal of the Royal Society.

155. Dollond, Peter, XX's (after **154**) son, 1766: removed from the Strand to 59, St Paul's Churchyard; 1791: also 35, Haymarket.

(1748): *A.* to ?.

1755. 03. 27: admitted as a foreign brother and sworn as a free *Sp.M.*; paid fine and fee.

1765: *A.* **368** (*N.C.*); 1770: *A.* **198**; 1778: **209** (*N.C.*).

1772: chosen *W.* in place of **143**, deceased.

1774. 10. 06; 1778. 09. 30; 1799. 10. 02: *M.*

1803. 10. 05: paid quarterage to the end of 1816; afterwards exempted.

XXI. Bird, John, mathematical instrument maker, 1749: first date, near New Exchange, Strand.

1764: opposed **155**'s Patent.

156. Motte, Phillip de la.

1749. 04. 27: *A.* to **127** (£100).

157. Scatliff, James, **115**'s son.

1749. 10. 05: *A.* to **115**.

158. Spillett, John (No. 2), son of John Spillett, soapmaker.

1749/50. 02. 05: *A.* to **87** (*G.W.*).

1757. 10. 06: free.

159. Lincoln, Suzannah, **87**'s daughter.

1749/50. 02. 05: *A.* to **87** (natural love and affection).

XXII. Bennet, John, 1749: first date, The Globe-Crown Court, Soho.

1764: opposed **155**'s Patent. Succeeded by James Search.

160. SMITH, Addison, nephew of Thomas Anderton of Westminster, vintner, 1764: Charing Cross; A. Smith & F. Watkins, partners, known from 1764 to 1774; 1764: St Martin's Lane.
1750. 10. 04: *A.* to **142** (£42).
1763. 06. 30: free.
1763: *A.* **358** (*N.C.*).
1764: had a law suit against **155** and signed the petition.
1789: last entry.
1783: *c.* 79, Charlotte Street, Rathbone Place, London; Patent spectacles, Brit. Pat. 1359/1783. 03. 13.

161. JONES, John, son of Rice Jones of St Martin's in the Fields, staymaker, 1776: *Sp.M.* Holborn.
1751. 03. 28: *A.*
1758. 10. 05: free.
1759. 10. 04: fined £2. 2*s.* for employing a boy not bound; fine remitted to £1. 1*s.*, he not being in good circumstances.
1760: *A.* **176** (£5); 1776: *A.* **207**.

162. FOSKETT, Robert.
1751. 03. 28: *A.* to **114** (£4).
1758. 05. 31: free.
1772. 06. 25: unanimously appointed *B.* by **147**, **155**, **160**, **122**, **113**, **119**, and **114** in **124**'s place.

163. SPINK, George, of Chatham.
1752. 03. 26: *A.* to **147**.
1759. 06. 28: free.

164. PYFINCH (also Pyefinch), Henry (No. 1), son of Henry Pyfinch of Hereford, gentleman, 1765: 64, Cornhill; 1782, 1791: 45, Cornhill.
1753. 06. 28: *A.* to **142** (£42).
1763. 03. 31: free.
1763: *A.* **187** (*N.C.*).
1765: at the great fire this year his shop was damaged and the brass tools stolen.
1791: *d.* before.
(1768): **155** brought an action against him for infringing his patent; judgment given against **164**, Michaelmas term 8. George III.

165. RICHARDSON, Winstanley, son of Ann Richardson, widow, 48, Leadenhall Street, 1807: Irongate.
1753. 10. 04: *A.* to **87** (*G.W.*).
1771. 03. 28: ordered to take up his freedom.
1773. 09. 30: free.
1775: *A.* **230**.
1807. 10. 01: *d.*

166. LINNELL, Robert, a foreign brother.
(1747): *A.* to ?.
1754. 10. 03: free.
1759. 10. 04: fined £5 for employing a boy not bound; reduced to 19*s.*
1754: *A.* **167** (*G.W.*); 1774: *A.* **204**.

167. LINNELL, Joseph (No. 1) (? identical with **204**), **100**'s son, late St Giles, Cripplegate, 1764: Ludgate Street.
1754. 10. 03: *A.* to **166** (*G.W.*).
1756. 06. 28: turned over to **173**.
1760. 10. 01: turned over to **118**.
1763. 06. 30: free.
1764: opposed **155**'s Patent.
?: succeeded in **135**'s place.

168. GREGORY, Samuel, son of Alexander Gregory, late of St Mary's, Islington, deceased.
1755. 10. 02: *A.* to **114** (*G.W.*).

169. HUMPHRIES, Richard.
1755. 10. 02: *A.* to **110**.
1761. 12. 31: turned over to **153**.
1763. 03. 31: free.

170. WITHERSPOON, John, optician, 1780: Little Bell Alley, parish of All Hallows, London Wall; 1783: White Lion Court, Bell Alley, Coleman Street.

171. LINCOLN, Charles, **87**'s son, 1763 Mortimer's Directory: Cornhill near the Poultry; 1791 Directory: 62, Leadenhall Street.
(1758): *A.* to ?.
1762. 04. 01: free by patrimony.
1765: *A.* **192**; 1778: *A.* **211**.
1787. 10. 03 to 1790. 10. 06: *M.* succeeded by **181**.
1807. 03. 26: Court informed of his death.

172. COURT, David, Leadenhall Street, haberdasher.
1762. 12. 01: admitted by redemption.
1765: his house having been damaged by the great fire in Cornhill, he removed to Corks opposite Jeffery Square, St Mary's Axe.
1764: *A.* **190**; (1767): *A.* **178**.

173. STERROP, Avis, **132**'s widow between 1756. 04. 28 and 1756. 05. 19.
1756: *A.* **167**.

XXIII. RAMSDEN, Jesse (*b.* 1731, *d.* 1800), married Sarah Dollond.
1758: *A.* to (J.) Burton, mathematical instrument maker.
1762: started business for himself opposite Sackville Street, Piccadilly. Harrison, an old workman of his, employed by the Hon. Henry Cavendish, stated that many of Ramsden's object glasses were made by **155**. In the case of a Ramsden small mahogany-body telescope equatorial in the Science Museum is a written label stating that the object glass was made by **155**.

174. Carter, James.
1758. 03. 31: *A.* to **114.**

175. Scatliff, John, **115**'s son.
1765. 06. 27: free by patrimony.

xxiv. Heath & Wing, 1759: "Hercules & Globe" next door to the Fountain Tavern in the Strand; for Heath see xii (after **109**).
1765: last date.
Succeeded by T. Newman.

176. Winter, Joseph, son of Joseph Winter, citizen and baker of London.
1760. 05. 06: *A.* to **161** (£5).

177. Agate, Mary.
1760. 05. 09: *A.*

178. Court, Susannah, **172**'s daughter.
(1760): *A.* to **172.**
1767. 07. 23: free.

179. Eglinton, Peter (No. 2), **119**'s son.
1760. 10. 02: *A.* to **119** (2*s.* 6*d.*).
1771. 10. 03: free on the testimony of **119.**

180. Blunt, Thomas (No. 1), son of William Blunt of Barnes in Surrey, shoemaker, 1798: 22, Cornhill.
1760. 12. 27: *A.* to **147** (*N.C.*).
1771. 03. 28: was ordered (with others) to take up his freedom, having served full time with a member of the Company.
1771. 06. 27: was admitted to the freedom, being late apprentice of **147** by indenture for the term of seven years, the master testifying; paid 17*s.* 4*d.*
1786: *A.* **244.**
1782. 10. 03 to 1794. 10. 01: *M.*
1822 Directory: Blunt, Thomas, succeeded by **194.**

181. Dollond, John (No. 2), **155**'s younger brother.
1767. 03. 26: admitted and sworn.
1782: *A.* **214** (*N.C.*); 1786: *A.* **220** (*N.C.*).
1790. 10. 06: *M.*
1792. 10. 03: *M.* succeeded by **180.**

182. Eastland, William (No. 2).
(1761?): *A.* to **102.**
1762. 09. 03: turned over to **153.**
(1768?): free.
1774. 06. 30: £1. 1*s.* was paid to **153** to get him out of Poultney Compter (debt).

183. Howe, John (No. 3).
(1761): *A.* to ?.
1768. 12. 29: free by patrimony.
1786: *A.* **221.**

184. Linnell, George, *Sp.M.*, Goldsmith Street, St Gough Square; 1804: Optician, 14, Cow Lane.
1769. 09. 12: free by patrimony.
1771: *A.* **201, 202** (£5); 1767?: *A.* **194;** 1778: *A.* **210.**
1783. 05. 13: bankrupt.
1784: paid quarterage to the end of.

185. Fairbone, Charles, 1780: New Street, Shoe Lane; 1786. 01. 03: mathematical instrument maker at same address (see for **220**'s age).
1787: *A.* **223.**
See also Fairbone & Ramsden.

186. Watkins, Francis (No. 2), son of William Watkins, vintner.
1763. 07. 06: *A.* to **160.**

187. Meridith, John, son of Thomas Meridith of Cumgallen, County of Radnor, farmer.
1763. 10. 06: *A.* to **164** (*N.C.*).
1782. 10. 10: free.
1800: last entry.

xxv. Adams, George (No. 2), xviii's (after **143**) son (*b.* 1750, *d.* 1795. 08. 14).
Succeeded by xxxii (after **227**).

188. Glover, John Arthur.
1771: *A.* turned over to him.

xxvi. Burton, John, Johnson Court, Fleet Street.
1764: opposed **155**'s Patent.

xxvii. Teatley, Robert, Fleet Street.
1764: opposed **155**'s Patent.

xxviii. Troughton, John, 1764: Surrey Street.
1764: opposed **155**'s Patent.
1791: J. & E. (the brother) Dollond, 136, Fleet Street.

189. Delafas, Joseph.
1764. 10. 31: *A.* to **147** (£21).

190. Court, William, son of John Court of Oxford.
(1761): *A.* to **172.**
1771. 09. 18: free by redemption.

191. Lloyd, John.
1765. 02. 14: *A.* to **110** (*N.C.*).
1769. 07. 07: turned over to **153.**

192. Cordett, Richard.
1765. 10. 03: *A.* to **171.**

193. Berge, John, son of John Berge of Wapping, Middlesex, 1791: from, Johnson Court, Fleet Street.
1756. 12. 26: *A.* to **155,** optician. (This is the first appearance of the term "optician" in the *Sp.C.*'s Journal (*N.C.*).)
1773. 09. 30: free; from then to 1791 with **155.**
1795: paid quarterage to the middle of.

194. HARRIS, Thomas, son of Thomas Harris, late of Newington Butts, tallow chandler, 1804.
1767. 09. 04: *A.* to **184**, *Sp.M.*
1804. 10. 03: admitted free by service to **184**.
Optician, 140, Fleet Street, and 30, High Street, Bloomsbury; 1817: Great Russell Street; 1822 Directory: 52, Great Russell Street, Bloomsbury.
1827: last entry.

195. WALKER, Samuel, Mark Lane.
(1767): *A.* to ?.
1774. 05. 31: free.
1817: paid quarterage to the end of.

196. RIBRIGHT, Thomas (No. 2).
1768. 10. 05: *A.* to **150**.
1775. 10. 05: free.
1806. 03. 27: in reduced circumstances; *Sp.C.* allowed him £1 a quarter.
1811. 07. 19: *d.* before; gift continued to the widow.

XXIX. PIERCE, Samuel (before 1770). W. Kitchiner, 1824, relates that Pierce was over thirty years a workman with XXIII (after **173**).

197. LONG, James, son of James Long, St George's, Southwark, gardener, 1791: Royal Exchange.
1769. 08. 14: *A.* to **147**.
1781. 10. 30: free.
1785: after, Long & Johnson.
1800: *c.* name on a shagreen spyglass.
1805. 10. 02 to 1807. 09. 30: *M.*

198. LECOUR, James (No. 2).
1770. 10. 03: *A.* to **155**.

199. SPENCER, Richard.
1778: *A.* **212**; 1782: *A.* **215**.

200. BLEULER, John, son of Jacob Bleuler, late of St Andrew's, Holborn, 1779 to 1791: address given as Mr Shuttleworth's, Ludgate Street; after that: 27, Ludgate Street.
1771. 01. 17: *A.* to **153** (£10).
1779. 10. 07: free.
1792. 10. 01: *M.*
1795. 09. 30: *M.* succeeded by **147**.
1811. 10. 02: *M.* succeeded by **223**.
1829. 08. 27: *d.*

201. FERGUSON, Daniel, of Edinburgh.
1771. 04. 16: *A.* to **184**.

202. DIXEY, Edward, son of John Dixey of St Mary's Overys, Southwark, fishmonger, 1822 Directory: optician, 335, Oxford Street.
1771. 08. 17: *A.* to **184** (£5).
(1778): free.

203. KING, Thomas (No. 2), author: Tilt Boat, Dark House Lane.
(1772): *A.* to ?.
1779. 12. 01: free.

204. LINNELL, Joseph (No. 2) (? identical with **167**).
1774. 10. 03: *A.* to **166**.

205. RICHARDSON, Richard (No. 2), **165**'s son.
1775. 10. 05: *A.* to **165**.

206. FLINDELL, John.
(1775): *A.* (? turned over) to **150**.
1782. 10. 03: free.

XXX. MARTIN, Benjamin & Son, 1776: see XIII (after **111**).

207. JONES, William (No. 2), **161**'s son.
1776. 11. 25: *A.* to **161**, a pupil of XXX (after **206**).
1831: paid quarterage till the end of; *d.* shortly after.

208. LONGMAN, James, 26, Cheapside.
1786: *A.* **222**.

209. HUGGINS, John, later, after ... John Dollond (No. 3).
1778. 01. 01: *A.* to **155** (*N.C.*).

210. CLARKE, William, of Windsor.
1778. 05. 28: *A.* to **184**.

211. BAILEY, Charles.
1778. 06. 11: *A.* to **171**.

212. SMITH, James, son of Ralph Smith, sen., Newington Butts, gardener.
1778. 07. 06: *A.* to **199**.
1785. 11. 29: free.
1785: *A.* **219**.
1827: last entry.

213. FIELD, John, son of John Field, citizen and apothecary, 1791 Directory: 74, Cornhill; 1817 to 1827: His Majesty's Mint.
1779. 10. 18: *A.* to **147** (£150).
1787. 02. 08: free.
1799. 10. 02 to 1801. 09. 30: *M.* succeeded by **155**.
1820. 10. 04 to 1822. 10. 02: *M.* succeeded by **224**.
1830. 04. 01: mentioned in a letter to the Company the good state of the Company compared with that of forty years earlier.

214. MOON, William, son of Francis Moon, Oxford, tailor, 35, Northampton Street, Clerkenwell.
1782. 02. 04: *A.* to **181** (*N.C.*).
1791. 10. 16: free.
1811: paid quarterage to the end of.

215. SMITH, Ralph, **212**'s brother.
1782. 12. 11: *A.* to **199**.

216. BARNETT, Thomas, scientific and mathematical instrument maker, 1789: 21, East Street, Lambeth.
(1782): *A.* to ?.
1789. 12. 17: free.
1804: paid quarterage to the end of.
1816: in the workhouse to the end of.

217. MORRIS, John (No. 2).
(1783): *A.* to ?.
1790. 01. 28: free.
1799: paid quarterage to the end of.
1812: *d.* probably.

218. RICHARDSON, George, 1807 to 1817: 7, St Katherine's Tower; 1826: 12, Upper East Smithfield; 1826: optician and gasfitter, 38, Windham Street, New Road, Marylebone.
(1784): *A.* to ?.
1791: free.

219. SMITH, John, **212**'s brother.
1785. 12. 01: *A.* to **212**.
1804: last entry.

220. FAIRBONE, John, **185**'s son.
1786. 01. 02: *A.* to **181** (*N.C.*).

221. ROSKELL, William.
1786. 01. 12: *A.* to **183**.

222. READ, George.
1786. 04. 03: *A.* to **208**.

223. DOLLOND, George, formerly Huggins, son of William Huggins of Russell Court, hatter, deceased.
1787: *A.* to **185**.
1807. 01. 15: admitted by redemption.
1811. 10. 20; 1813. 10. 06: *M.*
1837: paid quarterage to the end of.

XXXI. TROUGHTON, Edward, see XXVIII (after **188**), 1788: Patent; 1822 Directory: 136, Fleet Street.

224. LAWSON, Henry, son of the late Rev. John Lawson, Dean of Battle, Sussex. 1817: 45, Gower Street; 1839: 12, Chancery Lane.
1788. 12. 06: *A.* to **147** (£200).
1796. 04. 12: free by servitude.
1803. 10. 05 to 1805. 10. 02: *M.* succeeded by **197**.
1810. 07. 08: The Company wishing to purchase £175 3% Cons., it was found a seal was necessary; one was ordered to be made and H. Lawson was entrusted with the execution of this order. Description of seal: Azure: a pair of compasses (Cheveron wise) between two pairs of spectacles in chief or and a terrestrial globe in base proper the frame and stand of the second. In the centre chiefpoint the achromatic prisms open also proper. Lawson was thanked for the plan and execution.

225. LAWSON, Johnson, **224**'s brother, 11, Bedford Street, Bedford Lane.
(1789): *A.* to **147**.
1796. 04. 12: free.
1813. 10. 06: *M.*

226. SHUTTLEWORTH, Henry, **153**'s son.
(1790): *A.* to **153**.
1797. 06. 27: free.
1811: last entry.

227. EGLINTON, Peter (No. 3) (? **179**'s son).
(1793): *A.* to ?.
1800. 02. 04: free.

XXXII. ADAMS, Dudley, XVIII's (after **143**) son and XXV's (after **187**) brother, 1793: Charing Cross; 1795: (after XXV's death) he removed to 60, Fleet Street; 1800: 6, Jewry Street, Aldgate; 1822 Directory: same address.

228. NEWMAN, James.
(1793): *A.* to ?.
1800. 10. 08: free.
1827: end of, last entry.

XXXIII. JONES, David (perhaps XXXIX's (after **240**) father); 1791 Directory: 35, Charing Cross.

XXXIV. JONES, W(illiam) and S(amuel), 1793. 02. 05 to 1822 Directory: 30, Lower Holborn. W. Jones was against W. H. Wollaston's innovations.

XXXV. WATKINS, Jeremiah, 1791 Directory: 5, Charing Cross, J. & W. Watkins; 1808 Holden Directory: 5, Charing Cross, Watkins & Hill; 1822 Directory: 5, Charing Cross.

229. WEST, Charles Robert, 1808 Directory: 23, Plough Court, Fetter Lane, optician; 1822 Directory: manufacturer, 5, Cursitor Street, Chancery Lane; 1824: end of, St James' Street, Pall Mall; *d.* then. His shop, Gateway of Lincoln's Inn.
(1794): *A.* to ?.
1801. 01. 03: free.

230. RICHARDSON, John, **165**'s son.
(1794): *A.* to **165**.
1801. 01. 15: free, 16, Somerset Street, Aldgate.
1807: paid quarterage to the end of.
1827: same address; probably *d.* then.

231. ABBOTT, Charles, *Sp.M.*, 6, Noble Street, Forster Lane.
(1794): *A.* to ?.
1801. 11. 17: free.
1827: same address.

232. Gilbert, William (No. 1), **237**'s father, son of John Gilbert, late of Postern Row, Tower Hill, optician, deceased, 1801: 148, Leadenhall Street, optician.
(1794): *A*. to ?.
1801. 12. 31: free by redemption.
1807. 09. 30 to 1809. 10. 04: *M*. succeeded by **200**.
1813. 06: *d*.

233. Fidler, John, son of Benjamin Fidler, Turnbull Street, coal dealer. 18th century: end of, *A*.

234. Jones, Samuel, son of ... of Wells Row, Islington, gentleman, 1806: 30, Lower Holborn, optician.
(1799): *A*. to ?.
1806. 09. 25: free by patrimony.
1839: paid quarterage to the end of.

235. Powell, George, *Sp.M.*, 69, Aldgate Street; 1816: Greenhill Street, Whitechapel.
(1799): *A*. to ?.
1806. 03. 05: free.
1819: salesman, Smithfield.
1828: last entry; address not known, fourteen quarters due.

236. Edginton, ..., 7, Charterhouse Lane, optician.
(1803): *A*. to ?.
1810. 11. 11: free.
1813: end of, last entry.

237. Gilbert, William (No. 2), **232**'s son.
(1806): *A*. to ?.
1813. 10. 06: free.
1813. 10. 07: succeeded **232**.
1833: last entry.

238. Bate, Robert Brettel, son of Overs Bate, late of Stourbridge, Worcester, mercer; 17, The Poultry, optician.
(1807): *A*. to ?.
1813. 12. 30: reference to a caveat having been entered by the Clockmakers' Company against the admission of Robert Brettel Bate as a freeman of this Company (*Sp.C.*) (he probably had some experience like this, as in 1807 he must have been about twenty-four years of age).
1822: *A*. **249**.
1828. 10. 01 to 1830. 10. 06: *M*.
1835: paid quarterage to the end of.

xxxvi. Watkins, W. (see xxxv (after **228**)), 1808 Holden Directory: 70, St James Street.

xxxvii. Varley, Samuel, *c*. 1800.

239. Winter, Thomas, a carpenter.
(1810): *A*. to ?.
1817. 02. 03: free.
1817: paid quarterage to the end of; went away then.

240. Pyfinch, Henry (No. 2), a grocer, 31, New Road, St George's in the East.
(1810): *A*. to ?.
1817. 12. 04: free.
1827: last entry.

xxxviii. Varley, Cornelius, 1811: Patent.

xxxix. Jones, Thomas (perhaps xxxiii's (after **228**) son), xxiii's (after **173**), pupil, 1811: Patent; 1822 Directory: 62, Charing Cross (see *The Mech*. vol. ii, pp. 242–3; Jones & Sons, Charing Cross. Rochon micrometer on a telescope in the Court Collection, Science Museum).

241. Blunt, Thomas (No. 2), 18, Ivy Lane.
1811. 03. 02: free.

242. Harris, William, Great Russell Street and 63, King William's Street, optician.
(1811): *A*. to ?.
1818. 02. 12: free.
1837: last entry.

xl. Tulley, Charles, see *Mem. Roy. Astr. Soc.* vol. ix, p. 283.

xli. Tulley, Thomas (probably xl's son).

243. Eden, William, a pupil of Andrew Pritchard, 1818 to 1827: 30, Castle Street, Holborn, optician.
(1811): *A*. to ?.
1818. 12. 03: free.
1827: last entry.

244. Blunt, Rev. William, **180**'s son, 1825: 12, Stainford Street, Blackfriars, clerk in holy orders.
1816. 06. 01: *A*. to **180**.
1825. 10. 11: free.

245. Patrick, George, 16, Finch Lane, optician.
(1816): *A*. to ?.
1823. 10. 14: free.
1827: last entry.

246. Blunt, Edward, optician, **180**'s son, late of Cornhill, optician, deceased.
1825. 01. 20: free by patrimony.
1827: last entry.
1827. 03. 27: petition for relief for Mrs S. M. Blunt, **246**'s widow; £5 given to her.

247. West, Francis, 83, Fleet Street, optician.
(1821): *A*. to ?.
1828. 07. 08: free.
1839: paid quarterage to the end of. Previous address: 17, Rupert Court, Drury Lane.

248. WHITBREAD, George, scientific and mathematical instrument maker, 11, Exmouth Street, Commercial Road.
(1821): *A.* to ?.
1828. 07. 17: free.
1839: paid quarterage to the end of.

249. BATE, Bartholomew, **238**'s son.
1822. 01. 24: *A.* to **238**.
1829. 01. 27: free.
1832: paid quarterage to the end of.

250. PRITCHARD, Andrew, 150, Fleet Street, optician.
(1832): *A.* to ?.
1839. 01. 09: free.

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ROSS' MODIFICATION OF THE HILGER INTERFEROMETERS FOR TESTING LARGE OPTICAL ELEMENTS

By O. G. HAY, A.R.C.S.

(Member of the Technical Staff of Ross, Limited)

MS. received, 31*st December*, 1929. *Read and discussed*, 16*th January*, 1930.

ABSTRACT. The instrument* is a modification of the Hilger lens and prism interferometer and is intended for use in testing and figuring large optical elements such as astronomical telescope objectives, coelostat mirrors, etc., where the free aperture of the test element is larger than the normal aperture of the interferometer.

A detailed description with drawings of the apparatus for testing optical systems of about 12 in. diameter is given and the importance of geometrical design of the various parts is emphasised. It is intended to construct the proposed interferometer for the purpose of ascertaining the possibilities and limitations of the method and then, with the experience derived from this instrument, to apply the method on a more ambitious scale.

Introduction

A CONSIDERABLE amount of literature is now available relating to the theory and practical application of the Hilger interferometer†, and it will not be necessary to illustrate the principle of the instrument.

The interferometer has now become well established in both laboratory and workshop, mainly due to the reliability of its indications and the simplicity of its use.

For testing and correcting systems of not more than 5 or 6 in. free aperture the Hilger interferometer is undoubtedly more convenient than other methods, but when the case of large aperture systems is considered it will be apparent that an accurately figured centre mirror of sufficient size to cover the whole aperture is impracticable. The proposed interferometer has been designed to overcome this difficulty and, by employing methods of optical compensation for mechanical errors, the size of the test element is limited by factors other than the dimensions of the centre mirror.

At present it is possible to test large aperture systems on a standard Hilger interferometer by observing small portions of the aperture at a time.

This method is somewhat analogous to a process adopted for testing optical surfaces. A small test plate is transferred from one position to another of a larger surface and the interference pattern observed. Small local imperfections of the surface would be apparent at once, but broader defects, extending over a larger area, would not be so easily detected.

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* British Patent 305,350/28 and corresponding foreign applications.

† For the first published descriptions of the Hilger prism and lens testing interferometers, see British Patent 103,832/16, and *Phil. Mag.* **35**, Jan. 1918 (49).

In the same way it is possible to carry out a rough test on an interferometer of a large optical element by displacing the axis of the element with respect to the interferometer axis. By this means, small areas of the test element are brought into the field of view and the pattern observed for each successive area.

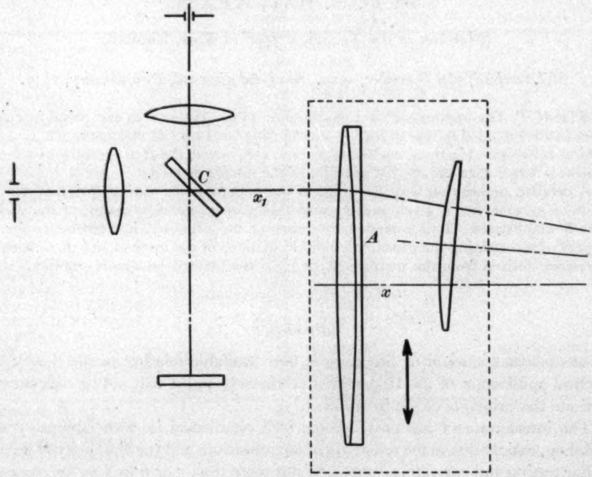

Fig. 1.

Fig. 1 shows a large lens *A* with its axis *x* displaced to one side of the interferometer axis x_1. The lens and convex mirror are mounted on a carriage and moved in a direction at right angles to the x_1 axis. All parts of the objective can be brought into the field of view by displacement of the carriage and rotation of the lens about its own axis.

This method would be quite useful for correcting small local defects in the wave front, but no true idea of the wave surface over the whole aperture could be obtained.

The problem resolves itself into finding some method by which the interferogram from one zone of the system bears a direct relationship to the interferogram of any other zone. This lack of relationship between the various patterns is brought about by mechanical errors. The movement of the carriage containing the optical system cannot be made sufficiently accurate to give the desired results.

Description of Method

Apparently, the only solution to the problem is to arrange that any errors introduced in the test beam, i.e. the beam containing the optical system under test, is compensated by a similar error in the reference beam. This has been carried out by definitely linking up the test beam and reference beam throughout the optical train of the interferometer.

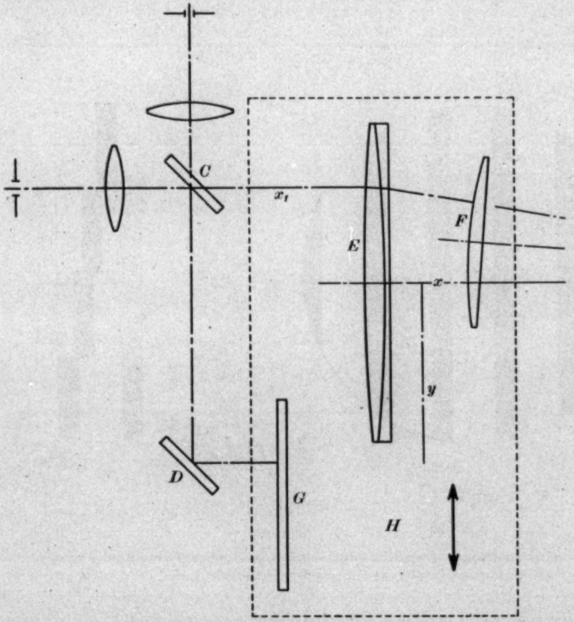

Fig. 2.

A simple modification of the standard instrument for obtaining this result is shown in Fig. 2. The reflected and transmitted beam from the centre mirror *C* are rendered parallel to one another by the plane mirror *D*. The test lens *E*, convex mirror *F* and a long reference mirror *G* are all mounted upon a carriage *H* travelling at right angles to the x_1 axis of the interferometer as before. While one beam from the centre mirror is made to impinge upon different zones of the test lens, the other beam is reflected from a corresponding position on the long plane mirror *G*.

The inaccuracy of the carriage in moving along the y axis may be analysed into translations in the directions of the x and z axes at right angles to the y axis, and also into slight rotations about the three axes x, y and z.

The two translations along the x and z axis will have no effect whatsoever on the interferogram, any increase or decrease in the optical path of one beam being neutralised by an equivalent increase or decrease in the length of the other beam. It is also apparent that rotation about the x axis can have no effect on the observed pattern. Small rotations of the carriage about either the y or z axes deviate the two beams to the same extent, that is to say, an angular deviation α of the carriage will deviate both beams by 2α in the same direction.

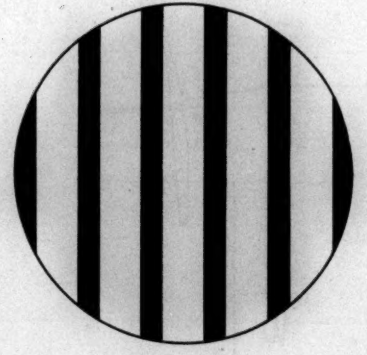

Fig. 3.

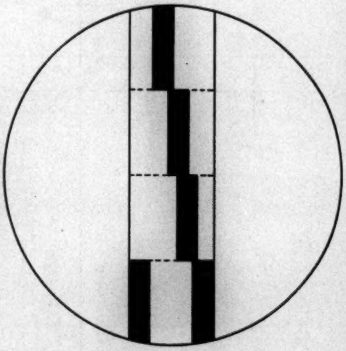

Fig. 4.

At the same time these slight rotations of the carriage introduce a difference in optical path length between the two beams. The only result of this difference of path is to cause a lateral displacement of the bands towards the high or low portions of the contour, the pattern otherwise remaining the same.

Fig. 3 represents the interferogram of a perfect telescope objective as it would be seen through an interferometer having an aperture sufficiently large to cover the whole lens at once.

Fig. 4 shows the pattern given by the same lens as seen through the modified instrument, four separate observations having been taken to cover the total diameter of the lens.

Alignment of the bands to form one continuous pattern can be obtained, if it is considered necessary, by introducing a slight difference of optical path length in one of the beams. This can be accomplished by rotating a parallel plate in one of the optical paths.

A more practical way of obtaining the same results is shown diagrammatically in plan and elevation (Figs. 5 and 6).

In this case the lens *E*, convex mirror *F* and long reference mirror *G* are mounted on a fixed frame in a position at right angles to the optical axes of the instrument. Two mirrors *K* and *L*, accurately adjusted parallel to one another, are fixed on a carriage *H* and are made to reflect the test beam and reference beam down on to the lens and reference mirror respectively. The carriage is moved over the main frame *M* of the interferometer, bringing the various zones of the lens under observation.

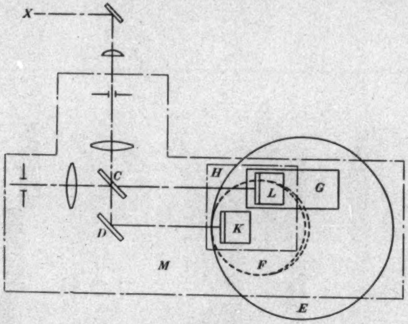

Fig. 5.

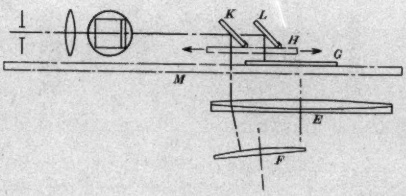

Fig. 6.

This construction has distinct advantages over the methods previously described. The carriage holding the two mirrors would be quite light compared with the heavy framework and carriage that would be necessary to mount the large lens, convex mirror, reference mirror and focusing adjustment. It is also more convenient to hold large elements in a horizontal rather than a vertical position.

Slight irregular movement of the carriage during its travel across the lens are compensated by the fact that both beams are deviated to the same extent.

Reflecting Surfaces

Up to the present the use of an independent reference mirror, common to all existing Hilger interferometers, has been maintained. This is not always advantageous, and a more convenient method can be employed in the testing of very large reflecting surfaces.

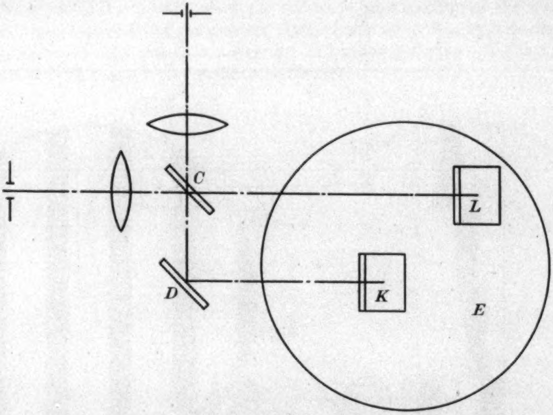

Fig. 7.

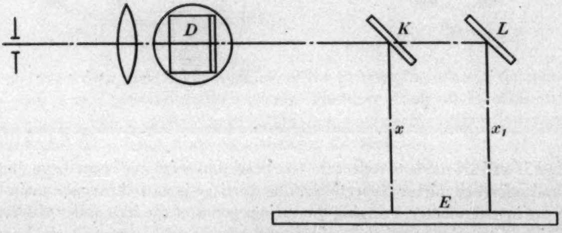

Fig. 8.

The principle underlying this construction is to select portions of the test surface as reference surfaces and make comparisons between them and the rest of the surface.

A simple application of this idea is illustrated in Figs. 7 and 8. Two mirrors *K* and *L* are placed parallel to one another and made to reflect both beams from the centre mirror down to the surface E, in this case a large plane mirror such as a coelostat mirror. The optical path of the two beams can be made equal by the correct disposition of the three mirrors D, K and L.

One beam is made to impinge upon the centre of the surface and the other includes a portion of the outer zone. The surface itself is allowed to rotate independently about the two axes x and x_1. During rotation about the x-axis, the central portion of the surface may be considered to be the reference plane and a comparison made with the various parts of the outer zone. A portion of the outer zone is then selected as a reference plane and the surface rotated about the x_1 axis. By this means the surface is tested for zonal defects lying between the centre and margin. There will be slight errors in movement while rotation is taking place about the two axes, causing angular deviation of the two beams from their true paths, but the error is automatically compensated for as in the other cases described.

With a little alteration to the components, the same arrangement can be used to test convex and concave surfaces. The spherical surface E, Figs. 9 and 10, is mounted with its centre on the optical axis x and, by tilting the mirror L, the other optical axis x_1 can be made to strike the outer zone of the surface normally. The test surface is rotated about the x and x_1 axes as before. An adjustment of the collimator lens N must be made to project the image of the diaphragm O into the centre of curvature of the test surface.

Errors causing Incomplete Compensation

The two beams reflected from the surface are not parallel to one another and compensation will be incomplete. Provided that reasonable care in centring is taken and the mechanism for revolving the surface about the axes is fairly accurate there will be no difficulty in this direction.

Two special cases will serve to illustrate the effect that will be produced on the results by errors in movement and centring. Each of the two beams converging to the centre C, Fig. 11, of a surface AOB strikes normally and is reflected back along its own path. During rotation the mirror takes up a new position A_1OB_1 due to inaccurate movement.

The beam EO will now strike at an angle α to the normal and will be reflected back at an angle equal to 2α. At the same time the beam FB will be deflected from its original path by slightly more or less than 2α, causing incomplete compensation.

The degree of compensation will depend upon the angle β between the two axes and can be derived from the following formulae:

$$\theta = 2\,(\alpha - \alpha_1)$$

and

$$\sin \alpha_1 = 2 \sin (\alpha/2) \cos (\beta - \alpha/2),$$

where θ is the angular aberration of the two beams.

The other case to consider is a lateral displacement of the surface at right angles to one axis, and is shown in Fig. 12. The surface AOB, having a radius r and its

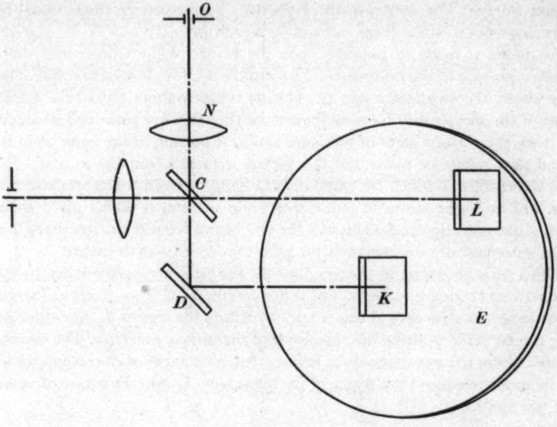

Fig. 9.

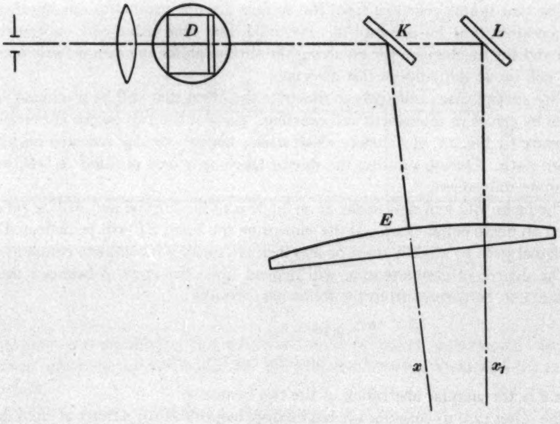

Fig. 10.

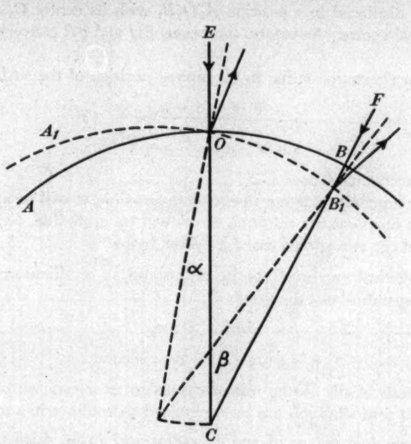
E
F
A_1
O
B
B_1
A
α
β
C

Fig. 11.

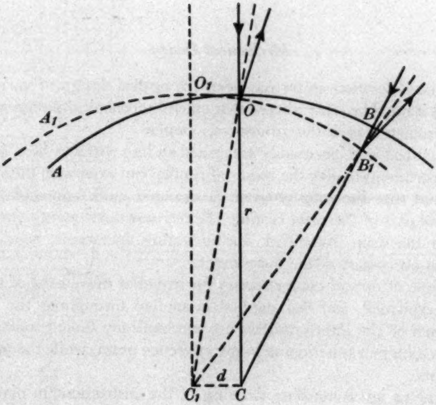
O_1
O
A_1
A
B
B_1
r
d
C_1
C

Fig. 12.

centre at C, is displaced to a position $A_1O_1B_1$ with its centre C_1 at a distance d from the original centre. As before, the beams EO and FB converge to the centre at an angle β.

The angular aberration θ due to the altered position of the surface is given by

$$\theta = 2(\alpha - \alpha_1)$$

and $$\sin(\alpha - \alpha_1) = \frac{d - d\cos\beta}{r}$$

for small displacements d.

Although compensation is not theoretically possible, it will be appreciated that for all practical purposes the resulting errors will be negligible.

Examples of the two special cases are given below.

Case I. Spherical mirror of 100 in. radius and 10 in. diameter is tilted by an angle $\alpha = 60$ seconds about the vertex O,

$$\sin\beta = 5/100,$$

$$\theta = 2(\alpha - \alpha_1) = 0{\cdot}14 \text{ second,}$$

so that 60 seconds of tilt on the mirror results in an aberration of the beams of 0·14 second and compensation has been obtained to within 1 in 430.

Case II. Spherical mirror of 100 in. radius and 10 in. diameter is displaced laterally by 0·1 in. at right angles to the optical axis.

$$\theta = 2(\alpha - \alpha_1) = 0{\cdot}52 \text{ second.}$$

Mechanical Design

The only consideration so far has been the optical design of various forms of apparatus, but it must be remembered that careful mechanical design and construction of interferometers is of the utmost importance.

Massive castings with accurately machined sliding surfaces have been used on this class of instrument to give the required results, but even with these precautions it will be found that the interferogram is changed quite appreciably by a little pressure on any part of the main casting. In the new instrument, where a carriage is moved over the main framework during testing operations, bending will take place in almost every part of the instrument.

The principle of optical compensation for irregular movement of the parts has already been explained, and this method is applied throughout the design. The various elements of the interferometer are mechanically linked together in pairs, one element in each pair functioning in the reference beam, while the other operates in the test beam.

Figs. 13 and 14 are a machine drawing of the instrument in plan and elevation respectively; diagrammatic representation of the design was shown in Figs. 5 and 6.

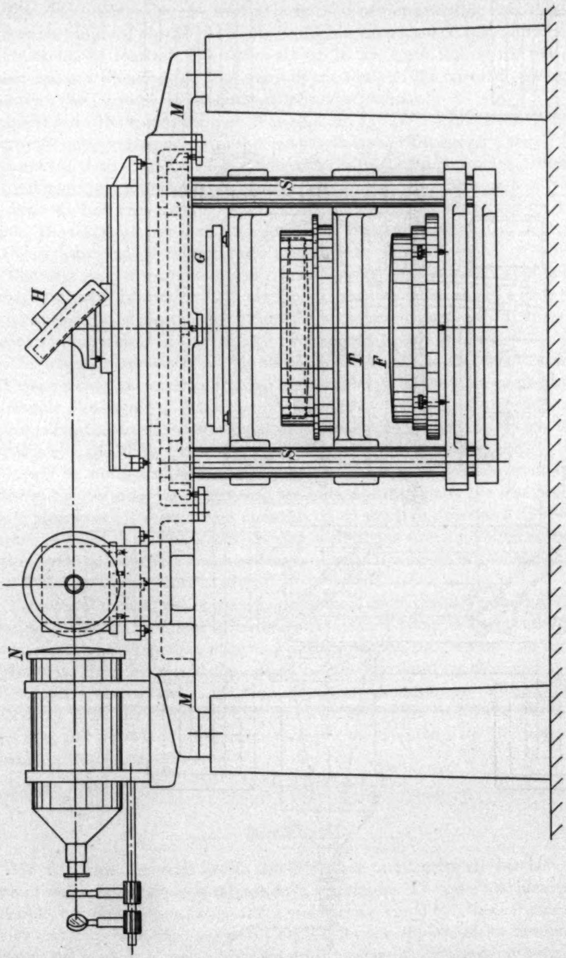

Fig. 13.

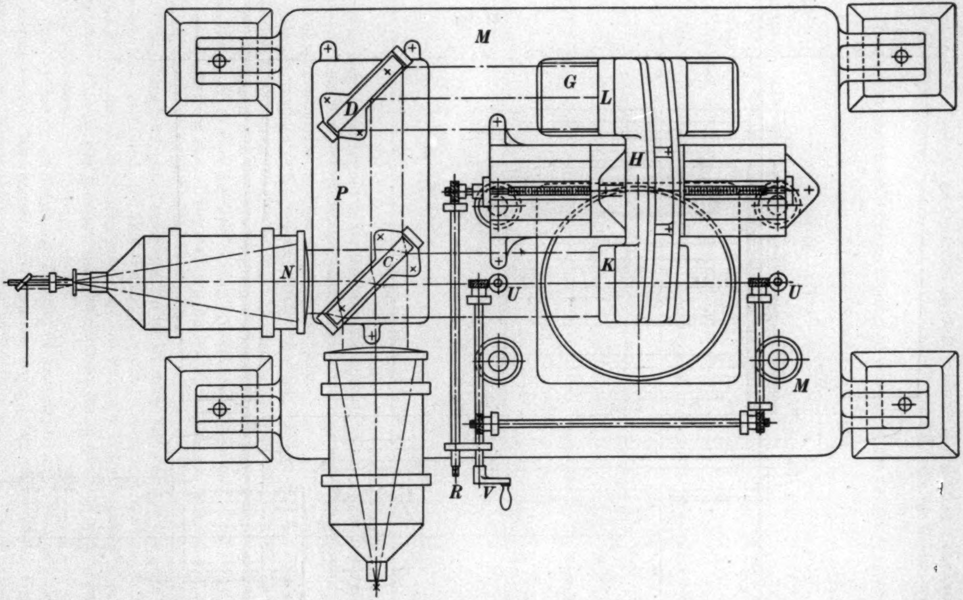
M
G
L
D
H
P
C
N
K
U
U
M
R
V

Fig. 14.

The centre mirror *C* and mirror *D* form the first compensating pair. These two mirrors are mounted rigidly to a frame *P* which is supported on the main casting *M* by six points of constraint. Stresses set up in the main casting tilt the mirror framework as a whole, and do not transmit the strain to the mirrors. Under these conditions the mirrors will remain parallel to one another.

Light from the collimator lens *N* is split up by the centre mirror *C* into two beams, the reference beam being rendered parallel to the test beam by mirror *D*. On the outward path there will be no deviation of the two beams from their true position when any tilting is given to the frame *P*. On the return path of the light the reference beam reflected by *D* will be deviated by 2α for an angular tilt α of the frame. The test beam reflected into the eye by the centre mirror will be deflected by 2α, so that complete compensation is obtained.

The next pair of mirrors *K* and *L* are mounted on a frame *H* resting on the carriage by point constraint. The carriage is made to move about a slide on the main casting, and its position is regulated by an adjusting handle *R*. Compensation of errors in movement of this carriage have already been explained.

The last pair consists of a long reference mirror *G* and the convex mirror *F*, both mounted on a substantial frame *S* and hanging from the main casting by point constraint. The degree of compensation obtained by this pair will depend upon the position of the centre of rotation about which the frame is tilted; but in any case the magnitude of this error will be too small to need further consideration.

It will be noticed that the usual procedure of moving the convex mirror for focusing has been departed from and the adjustment given to the lens itself. The lens is placed on a rotating fitting mounted on an adjustable carrier *T*. This carrier is made to move on a vertical slide formed by four posts rigidly bolted to the main casting, and the focusing of the test lens is obtained by means of two geared screws *U* operated by a convenient handle *V*.

The optical path length of the whole system is approximately adjusted, and any substantial thickness of lens introduced in the test beam is compensated by a displacement of the reference mirror. For convenience, the reference mirror frame is placed on three balls, and the optical path is equalised by changing them for balls of a different diameter. At the moment an interferometer is being made in accordance with the principles laid down in this paper to handle plano plates, objectives and mirrors of a maximum diameter of 12 in. with an interferometer of normally 4 in. clear aperture.

DISCUSSION

Mr T. Smith: I should like in the first place to congratulate Mr Hay on the work of which he has given so interesting a description. The principal idea involved is simple, but only obvious when it has once been pointed out; were it otherwise it would certainly have been suggested earlier, for the application of the interferometer to the working of large objectives must have been considered by a number of members of the industry. I am particularly pleased to see this further application of the interferometer to problems of optical manufacture, because, coming as it does from one of the leading British optical houses, it indicates that the value of Mr Twyman's interferometer is being appreciated by some at least of our leading instrument makers. I hope that this will induce some other firms, who may have been uncertain how useful such an instrument would be to them, to give this question fuller consideration. The invention of the lens-testing interferometer seems to me one of the most important events in our recent history, and I should like to see our own firms deriving the utmost assistance from it. I hope we shall have an opportunity, at some future date, of hearing that an instrument of this new type has been built and has fulfilled the expectations of its makers.

Prof. L. C. Martin: I should like to congratulate Mr Hay on this interesting work. Has an instrument on these lines been actually constructed yet? Will he explain whether it is intended to use the apparatus for testing large astronomical O.G.'s? It would presumably be necessary to use auxiliary convex mirrors which would somehow or other have to be tested as well. Would you make a series of long radius mirrors to suit the various objectives that might be called for? I believe that the principle developed in this paper will considerably extend the usefulness of the interferometer.

Prof. A. F. C. Pollard: Mr Hay, who is an old student of the Technical Optics Department, has read an excellent and interesting description of a notable advance in the design of interferometers, and both he and Messrs Ross are much to be congratulated.

It is not possible of course to offer any useful criticism until the instrument is constructed, but perhaps Mr Hay will allow me to remind him that, in order to secure the full advantages of kinematical design, the surfaces of the "point" constraints, one of which is convex and the other plane, should be dead hard and polished.

The common steel ball is an ideal bearing "point" and the surface with which such a ball contacts should also be a dead hard polished steel surface.

In some instruments designed on kinematical principles the convex surface of a constraint contacts with a cast-iron plane surface. A cast-iron surface is generally pitted and, even though no relative motion at the constraint may be designed to take place, differential expansion or elastic bending frequently causes relative shifting at the contact. The result might be troublesome in a superlatively delicate instrument since, on replacing a removable part, the contact at a constraint may now take place at some other point just over a pit in the cast-iron surface, and the previous adjustment therefore may be upset. When precise relative movement is designed to take place at the constraints the use of cast-iron surfaces is prohibitive, for this reason.

If wear is not to be tolerated the constraints should include rolling elements or "shoes" with three degrees of freedom. A ball-bearing slide, designed on kinematical principles and constructed with dead hard polished steel surfaces, permits precise relative motion with minimum friction and wear.

Though the errors of movement of the slide in the instrument described are in part optically corrected, manufacturing limits are eliminated in correct design and do not add to the cost of producing precise mechanisms. Moreover, ball-bearing slides may be designed for almost any load by increasing the number of balls previously selected by careful gauging.

J. Hasselkus: The instrument described by Mr Hay is not a theoretical design only, but the underlying principles have been carefully studied on a trial instrument which has been built up roughly on our 4-inch Hilger interferometer. We feel confident from the results obtained that the present design of instrument will do all that is expected from it.

The design is really of a tentative nature to enable us to judge how far the method will reach. I make no secret of the fact that one of the objects of the instrument is to figure large astronomical objectives and mirrors. We hope to gain sufficient information on the small instrument described to launch out into something very much more ambitious.

Mr O. G. Hay (communicated): I should like to thank Mr Smith for his encouraging remarks and agree that the principles of the design are simple. I can only hope that in carrying out the design greater difficulties will not be found than those already anticipated.

In reply to Prof. Martin I would say that the principles of the idea have been demonstrated on a Hilger Lens-Testing Interferometer of 4 in. aperture by introducing small mirrors of about 1 in. aperture. This is, in effect, an application of the design on a small scale.

A number of accurate spherical mirrors, constructed by methods laid down in the paper, will be a necessary part of the equipment. The size of astronomical telescope objective that can be conveniently handled on an interferometer will be determined by experience. I thank Prof. Pollard for his helpful suggestion and agree that full advantage will have to be taken of the use of kinematic design in an instrument of this type. Point constraint has been introduced for the elimination of strain rather than for obtaining accuracy of position or movement.

In certain parts of the design accuracy of movement is quite immaterial, perfect rigidity being the only essential factor.

DEMONSTRATION OF A PARABOLIC MIRROR

By S. J. UNDERHILL

(Adam Hilger, Ltd.)

Demonstrated, 12th December, 1929.

The mirror shown differed from the ordinary parabolic mirror as used for search lights, motor cars, etc., in that whilst the star image yielded by the latter is a point situated at the focus of the mirror surface, that of the former was a straight line image in the focal plane of the same length as the width of the mirror.

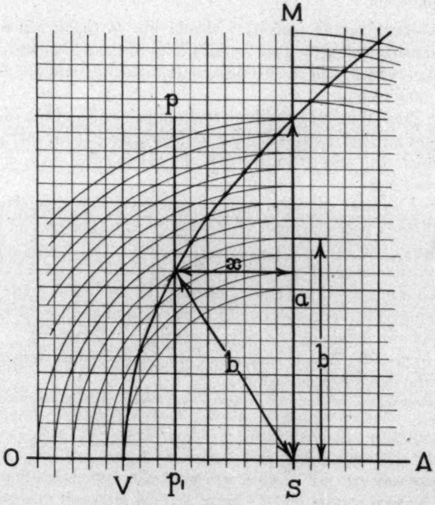

Fig. 1.

The width of the mirror was 6 cm., and the length measured along the parabolic surface 12 cm. The length of the latus rectum *SM* (see figure) passing through the centre of the mirror surface was 17·5 cm. The surface was ground on a rectangular glass blank to a template cut to a parabolic curve, optically polished, chemically silvered and the silver layer polished by hand.

The method of generating the curve for the template was evolved from the simplest principles of the wave theory by the man who worked the surface, and independently of any geometrical knowledge. His argument may be presented thus: A parabolic mirror reflects the light from a point at its focus so that after reflection it has a plane wave front. Now the plane wave front which passes through the focus is also the latus rectum plane, the dimension of which has been given. It is for this reason convenient to build up the parabola about this plane, or, as the parabola is a symmetrical curve about its axis OA, one half of the curve is sufficient for the present purpose.

As no refraction or retardation takes place geometrical equality of path from source to wave front is implied. For this reason the vertex must be situated at half the latus rectum length along the axis. Similarly, if the latus rectum length is broken up into any two parts, one part will be the distance from source to mirror and the other part will be the distance from mirror to latus rectum wave front.

A convenient method of plotting these distances is to describe a number of arcs with the focus as centre and for each radius to set off the remaining part of the latus rectum length (after deducting the radius) from the plane through the focus perpendicular to the axis. Each point of intersection so found is a point on the required parabola.

The above can be expressed thus:

If a is the length of the latus rectum, b is the radius of arc struck from the focus, x is the distance that the light wave has to travel from the mirror to the focal plane, then $a - b = x$.

If the parabola is to be plotted on a metal sheet it will be found convenient to draw lines pp_1, parallel to and at distances from SM as determined by the formula, as this tends to greater accuracy.

REVIEWS

Joseph Fraunhofers Leben, Leistungen und Wirksamkeit. Nach Quellen geschildert von MORITZ V. ROHR. Pp. xx + 233; 39 Figs. and 1 Plate. (Leipzig: Akademische Verlagsgesellschaft m. b. H., 1929.) Price R.M. 13, bound R.M. 15.

No one better qualified than Prof. Moritz v. Rohr could have been chosen to record the life and accomplishments of Joseph Fraunhofer, the needy, almost destitute orphan, the self-taught, inexperienced youth, and the forceful, ambitious, coldly critical and rather friendless man who died of overwork and consumption at the age of forty in the year 1826. From an imposing mass of material—clearly the accumulation of many years of research—the author has sifted out the more significant happenings which, arrayed in orderly sequence, convincingly portray the circumstances of Fraunhofer's too short life. The biography is characterised by its frankness and freedom from bias or favour, with here and there a very pardonable pride in "our Hero" who invested with such lasting prestige the growing optical and fine mechanical industry of nineteenth-century Germany.

Fraunhofer was born in 1787. Thirteen years later his father died. It was physical weakness that determined the boy's apprenticeship to the trade of glass-grinding. A serious accident from which he providentially escaped—the collapse of the house in which he was living—brought him to the notice of Utzschneider and the Elector Maximilian, who apparently took part in the work of rescue. Maximilian compensated the young Fraunhofer with financial liberality. This money he spent and mostly lost in two business ventures which quickly failed. With the residue he purchased his release from the last nine months of his apprenticeship.

To Utzschneider he owed more than he appeared either to recognise or credit, for it was this successful business man and manufacturer who facilitated his self-instruction and spare-time schooling, who gave him employment, and in a remarkably short time promoted him to managership and an interest in his establishment. But just as the famous old man, Guinand, was displaced to make room for the young and vigorous manager, so ultimately Utzschneider himself was practically set aside by the now indispensable and all-powerful Fraunhofer. Disagreement on questions of policy concerning the prices of contracts is suggested as a possible cause of the unfriendly feeling that appears to have separated these two men, upon whose harmonious collaboration the future of the Institute necessarily depended.

On July 7th, 1826, Fraunhofer died, leaving no one sufficiently informed or trained to carry on the work that had become the pride of the State.

Fraunhofer's name will never be dissociated from the dark lines of the solar spectrum which, in fact, had been discovered fifteen years before by Wollaston, who fully described and discussed the appearance of seven of them. With the practical ingenuity for which he was renowned, Fraunhofer perfected the means whereby these lines could be displayed and their positions measured with precision and thus be made to serve as valuable identification marks. It is characteristic of Fraunhofer that he improved and applied the discoveries and work of others, of which perhaps he was unaware, although no one could have been better placed than he was to know of all that occurred in the scientific world around him.

Wherein the greatness of Fraunhofer lay is well expressed in the final paragraph of the author's sympathetically critical appreciation of Germany's "first and distinctive Optician," whom his countrymen honour, "denn er war unser."

JAMES WEIR FRENCH.

Photoelectric cells. By Dr Norman R. Campbell and Dorothy Ritchie. Pp. vi + 209. (London: Sir Isaac Pitman and Sons, Ltd.) Price 15*s.* net.

Writing in 1920 on important lines of research in physics, a prominent laboratory director remarked that the photoelectric effect "has not, up to the present, found any industrial application; yet it may safely be prophesied that it will be of importance to industry within the next ten years." This prediction has been fulfilled well within the allotted time. Sound pictures now call for a manufacturing programme of some thousands of photoelectric cells weekly, the growing arts of picture transmission and television depend entirely on photoelectric cells, the practical rating and measurement of incandescent lamps is more and more being done by photoelectric means, and a surprising variety of control problems in engineering are being solved by the use of light beams falling upon these "electrical eyes."

While much has been written on photoelectricity and the photoelectric cell, not all has been of immediate value to the growing army of those who are keen to put it to use. On the one hand are the accounts of purely scientific studies in the various journals of physics, on the other hand the highly imaginative and often inaccurate articles in popular radio magazines. The serious worker has needed a reliable and authoritative book which shall be accurate in its theoretical background, and practical and detailed in its treatment of the uses and applications of photoelectric cells and auxiliary apparatus of types now available.

Photoelectric cells, by Dr Campbell and Miss Ritchie, meets this need extraordinarily well, and should prove a timely and valuable book. It is simply and logically arranged in three parts: "Theory of Photoelectric Cells," "Use of Photoelectric Cells," and "Applications of Photoelectric Cells."

The treatment of the theory of photoelectric cells and the photoelectric effect is clear and interesting, although perhaps too much is sacrificed in places to making it apply directly to commercial designs of cells. For instance, one gathers that the two extreme types of cells—as far as physical arrangement is concerned—are "spherical" and "plate," where the spherical cell is one with the sensitive metal on the walls, and a central anode. The spherical cell with small central cathode, giving a saturation current with no applied field, which is the type of most importance in theoretical studies of photoelectricity, is not described at all. In fact, the "stopping potential" which is measured in cells of this type for determining the Planck-Einstein constant h photoelectrically is not mentioned, and the well-established term "stopping potential" is used, unfortunately, for a gas discharge characteristic. One comment of the opposite nature may be made with regard to the treatment of the illumination-current relationship. This, while theoretically, and probably actually, under ideal conditions, rectilinear, has been found in practically all accurate experimental work, to be deviated from, in commercial types of cells, by significant amounts. This is a matter of such importance that it deserves a chapter to itself, coordinate with that on the voltage-current characteristic, giving experimental data showing the amount and kind of deviation from the simple direct proportionality law. Otherwise, although the reader is given a warning (not specific) against "misinterpretation," there is danger that the statement "it is accurately true" may cause him trouble.

The section on the use of the cell is admirable. A very complete account is given of the various methods of measuring photoelectric currents, both directly, by galvanometer or electrometer, or by utilising the newer amplifying methods for which the photoelectric cell, by reason of its high impedance, is so well and, from the standpoint of practical utilisation, so providentially suited. Particularly valuable is the attention given to the limitations of each method, and the conditions under which errors are introduced. Careful study of the conditions under which an electrometer using the "drift" method will give a reliable reading with a photoelectric cell should be urged on all who are under-taking the use of the cell for scientific measurements demanding high sensitiveness. The effect of a high resistance used in series with a gas-filled cell on the illumination-current relation is a matter of considerable importance in practical applications, such as sound pictures. A common pitfall is to boost the resistance, in order to obtain a greater voltage drop, to the point where serious distortion is introduced. A set of curves showing the effect of high series resistance with a typical gas cell might profitably have been shown.

The applications of the photoelectric cells are listed under "luminous flux," "illumination," "colour" and "absorption," that is, to problems of light measurement, although picture transmission, television, sound pictures and control problems are mentioned. Probably a future edition of the book will devote relatively more space to uses other than photometric. These other uses are indeed treated in a rather less careful manner than where the authors are dealing with the problems with which they have personally been chiefly engaged. For instance, it is not true that in picture telegraphy as contrasted with talking films "the cell has usually to distinguish only between two grades of illumination." With only one exception—transatlantic radio, where interference is serious—the commercial picture transmission systems use "grading" as the authors call it. Again, in speaking of the use of cells with fluctuating light it is said that "Frequencies much greater than 10,000 need hardly be considered for they do not arise in any application that has been made so far." Yet the reference given for information on television describes a system using twice this frequency, and systems transmitting far more detail, in which the behaviour of the photoelectric cell to high frequency stimuli will be a vital factor, are clearly demanded for a television service of any value.

The description of methods for using the photoelectric cell in photometry is practical and accurate. The point of view that the ideal is to use the cell exactly as the eye is used is one that all will not subscribe to. Visual photometry is carried out entirely by balancing or null methods because of the unsuitability of the eye for any process of evaluation except approximation to equality. The popular demand for an "electrical eye" for photometry is almost always based on the belief that it will do away with the necessity for a balancing method, with its additional "comparison lamp," and substitute for it the direct reading of a pointer on a scale. Were the illumination-current relationship accurately rectilinear in all cases, and could cells be produced which uniformly copy accurately the wave-length response characteristics of the eye, this ideal could be achieved, and the measurement of illumination would be as simple as that of electrical voltage or current. Unfortunately, we have not achieved cells of the characteristics demanded, and photoelectric photometry is as much confined to the laboratory as is visual photometry. That it can be made to give results of value in spite of its failure to meet the earlier high hopes entertained of it is a happy consolation.

These points, on which the reviewer differs from the authors in point of view or in his idea of proper perspective, are however of secondary importance. The really important thing to emphasise is that no prospective user of photoelectric cells can go far wrong if he thoroughly masters the information contained in this book. It is to be highly recommended.

H. E. I.

Physiologische Optik (*Handbuch der Experimentalphysik*, Band 20, Teil 1). By Dr A. König. Pp. vii + 241; 70 Figs. (Leipzig: Akademische Verlagsgesellschaft M.B.H., 1929.) Price RM. 22, bound RM. 23.60.

In this book, whose preparation was commenced by the late lamented Prof. C. Pulfrich, Dr König, one of the most senior of the co-workers of the Zeiss establishment, has treated physiological optics from the physical rather than from the biological, physiological, or psychological standpoints. Since, of late years, very few standard works on this subject have been the work of physicists, this book is well worthy of attention. It can be considered to be a valuable supplement, on the physical side, to Helmholtz, just as Hofmann's *Raumsinn des Auges* is invaluable as a modern appendix to Helmholtz on the physiological side.

Dr König deals with the structure of the eye, colour-vision, rod and cone vision, threshold phenomena, after-images, heterochromatic photometry, visual acuity, optical illusions, depth-perception, binocular contrast, etc. He has referred the reader to a large mass of modern work on these subjects: nor has he restricted his references to modern German researches. He has given full consideration to British and American workers, such as McDougall, Guild, Sherrington, Ives, Allen, and others.

In a book of such small dimensions, covering so wide a range, it is impossible to avoid compression of the subject-matter and this leads, in some places, to a certain obscurity, in others, to a certain dogmatism of statement, which is probably unavoidable. The text is excellently printed and very free from typographical errors: the diagrams sometimes fall short of the high standard of the text.

The chapter on the structure of the eye might have been improved by the reproduction of modern microphotographs instead of the well-known diagram of the section through the retina. Colour-vision and colorimetry are excellently treated. On p. 154 it is stated that the resolving power of the eye increases until the pupil diameter reaches 3 mm., remains unchanged until the diameter reaches 5 mm. and then decreases with any further increase of pupil diameter. But to define resolving power explicitly it is necessary to specify the exact type of test-object used. With certain test-objects it has been found, for instance, that the maximum resolving power for an ametropic eye is reached with a pupil diameter of 2 mm.

McDougall's name is incorrectly spelt throughout and is entered under Dougall in the index of names.

The chapters on the correspondence of the retinae and on the relative localisation of depth are excellent: those on optical illusions and binocular mixing are less convincing, but perhaps, for the present, their treatment is better left in the hands of the psychologists.

Dr König is to be congratulated on having produced an exceedingly useful and well-informed book which contains modern material, which cannot be obtained in such small compass elsewhere, and this book should prove a valuable work of reference to all workers in physiological optics.

N. M. S. L

ABSTRACTS OF PATENT SPECIFICATIONS

288416. Baker, T. Y., and another. THEODOLITES.

Images of opposite graduations of the divided circles are projected into different parts of the field of view of a single eyepiece by suitable optical systems, a datum mark being seen between the adjacent ends of the two images. A fine motion device controlling displaceable elements is operated to set the datum mark symmetrically between adjacent marks of the two images.

288613*. Quartzlampen Ges. REFLECTORS.

An area of concentrated illumination is obtained by mounting a quartz lamp or other straight line source within a trough-shaped rear reflector, from which the light is directed into a second funnel-shaped reflector opening below upon the surface to be illuminated. The second reflector is parabolic in axial section in one plane, and flat sided in the other.

288694. British Power Railway Signal Co., Ltd., and others. LENSES.

Consists of a compound lens for use in signal lamps or projectors. Portions of different focal length or with distinct optical axes are combined into a single unit, which may be employed in conjunction with one or more sources of light, so as to produce separate beams having the required direction and distribution of light.

288747. General Electric Co., Ltd., and another. PHOTOMETERS.

Light is detected or measured by means of the change produced in the normally unstable part of the characteristic of a photo-electric cell due to the variation of the illumination. Stability is obtained by introducing a current-limiting device, such as a thermionic valve.

288967*. Goerz Optische Anstalt A.-G. PERISCOPES.

A complete panoramic view is obtained by employing a circle of optical systems, one part of each of which is fixed, the other part being capable of rotation about the centre line of the group. The respective fields of view build up into a complete image, without gaps.

289831*. N. V. Nederlandsche Instrumenten-Cie. TELESCOPES.

A sighting telescope for use on a moving platform is adjustable about vertical and horizontal axes, and the sighting line is displaced by tilting an entrance reflector about a third axis. A gyroscope in conjunction with an optical system enables the main casing of the instrument to be maintained with its axis vertical, this adjustment being made by a separate observer.

289886*. Kodak Ltd. LENS MOUNTS.

Lens mounts and accessory fittings are so constructed that the necessary operative connection can only be made when the parts are in the correct relation, whether as to angular position, working aperture, or otherwise.

289926. Barr and Stroud, Ltd., and another. OPTICAL APPARATUS.

The field of view of apparatus such as described in Specification No. 287608 is divided into two parts, each limited to deal with displacements in one direction. An optical system is described by which two fields are combined for observation in a single eyepiece, one field having been turned through a right angle.

R. J. T.

* Specification published before acceptance.

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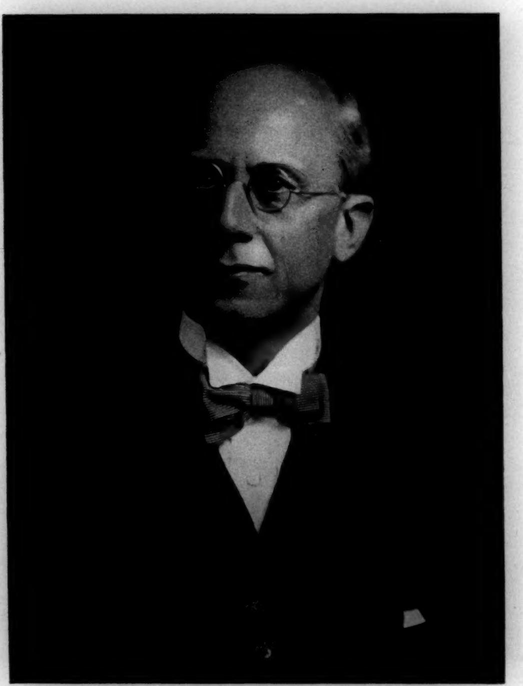

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1929–31